Sky and TELESCOPE

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COVER: Comet Wilson 1961d, photographed by Alan McClure of Los Angeles, California, on July 25, 1961, two days after its discovery by air navigator A. Stewart Wilson (see letter on this page and page 124). Exposure was five minutes on a blue-sensitive plate with a 7-inch f/7 telescope from Mount Pinos, California, elevation 8,828 feet. Note the faint sunward tail below the comet's nucleus.

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LETTERS

Sir:

Thank you for your invitation to write an account of my discovery of the new comet.

Sunday morning, 23 July 1961, I was navigating a Pan American 707 Jet from Honolulu to Portland. It was 11:35 Universal time; position 37° 05′ north, 138° 10′ west; altitude 29,000 feet. Only a trace of zodiacal light was visible in the east and dead ahead the star Theta Aurigae had just come over the horizon. The stars rise very rapidly when one is traveling eastward at over 10 degrees of longitude per hour.

Following Theta was a faint wisp of light as from a distant searchlight. The others in the cockpit thought it was a trace of aurora, but observation with a pair of 8 x 30 binoculars showed that it was not moving relative to the stars nor changing in brightness. As it rose, the wedge of light finally narrowed to a point near Tau Geminorum. A definite nucleus was visible with the binoculars. I estimated its magnitude as 3½, equal to nearby Theta Geminorum.

My associates in the airplane were not among the followers of Tycho Brahe and unfortunately did not appreciate the significance of what we saw.

I was home by 7:45 (Pacific daylight time) and learned that my wife had heard no reports of a new comet and there was nothing in the morning papers. I tried to phone Harvard Observatory to see if the comet had been reported. It would have been visible to favorably located observers all the way across North America and possibly Europe. There was just the possibility it had been missed.

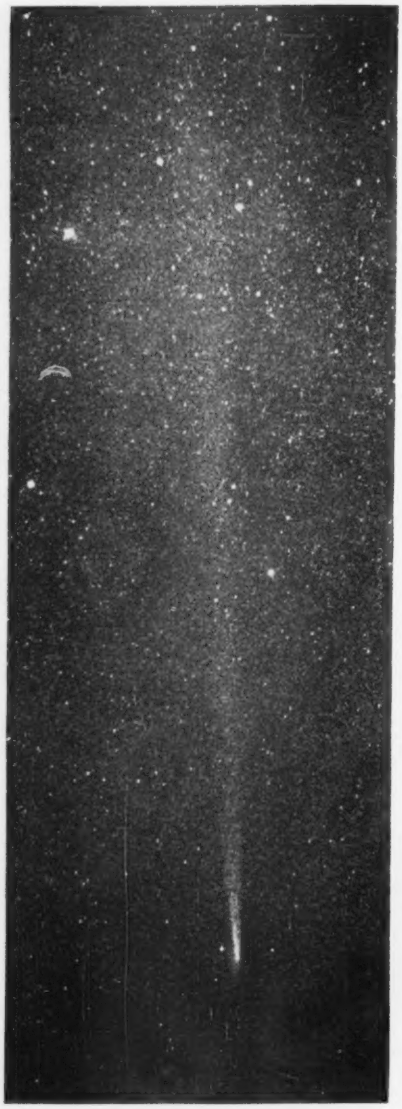
Unable to contact Harvard or the Dominion Astrophysical Observatory in Victoria, British Columbia, I called Prof. T. S. Jacobsen of the University of Washington at his home. He had received no news of a bright new comet and concurred that I should send Harvard a telegram.

Monday morning was cloudy until after sunrise and I had a trip to Fairbanks, Alaska, and back, flying as copilot. When I returned home that evening a telegram had arrived: "Your discovery of Comet Wilson 1961 confirmed. Announcement card will follow. Thank you. Robert O. Doyle, Harvard College Observatory." My wife had been answering phone calls all day.

Many others have searched longer and far more diligently for such things, and their efforts have often been unfruitful. Suddenly and with no effort I am virtually knocked on the head with a new comet. I am certainly delighted, but it seems somehow unjust.

A. STEWART WILSON
610 S.W. 207th Place
Seattle 66, Wash.

Comet Wilson 1961d



The first bright comet of 1961, photographed by Lester Bergquist and Jack Harvey with a 50-mm., f/1.8 lens. The exposure was 3½ minutes on 103a-F emulsion. It was made on June 26th at 11:33 UT from Mount Pinos. Note the long, thin secondary tail at the left, and the stubby antitail.

UNTIL late July, the year 1961 had seemed a quiet one for comets, the only three discoveries being very faint periodic objects whose returns had been predicted. This lull ended abruptly with the appearance in the morning sky of a conspicuous naked-eye comet, 1961d.

Although visible only for a brief interval before dawn, the comet was independently detected by many people. The earliest sighting known was by A. Stewart Wilson, on July 23rd at 11:35 Universal time, as he was navigating a Pan American jet airliner from Honolulu to Portland, Oregon. The details of his discovery of the 3½-magnitude comet near Tau Geminorum are given in his letter on page 123 of this issue.

The privilege of the first discoverer of a comet to have it known by his name appears to belong to Mr. Wilson, and therefore 1961d is called Comet Wilson.

At least six other observers were rewarded with unexpected views of Comet 1961d on the following morning, the 24th. Three of these independent discoveries were also from aircraft.

Near Seville, Spain, a U. S. Air Force technical sergeant made the second known sighting of Comet Wilson at 3:40 UT, only 16 hours after the original discovery. Paul W. Bailey's detailed report to Harvard Observatory states that the tail pointed nearly straight up from the horizon to an altitude of 35 degrees, as seen in binoculars. By 4:15, when the comet's head was 10 degrees above the horizon, the tail was fading in the dawn, and by 4:40 nothing of the fine object remained visible.

A. W. Stainback was captain of a United Airlines DC-8 jet that had left Honolulu at 9:30 UT on July 24th and was due at San Francisco at 14:12. About 10:22, flying at 33,000 feet above the Pacific, he became aware of an "unusual light beam" extending upward from the northeast horizon, slightly left of straight ahead. Although resembling an auroral feature, the beam was steady and sharply defined.

At 10:48, with the plane cruising at 37,000 feet, the object was brighter and higher in the sky, unmistakably the tail of a comet. The tail was three degrees wide, its right edge touching Theta Aurigae. About 40 minutes before sunrise, the comet's 3rd-magnitude nucleus rose above the horizon. Capt. Stainback and his crew members lost sight of the comet 25 minutes later in the growing light of dawn.

A similar experience was reported by Capt. I. C. Parks, flying an American Airlines jet from Los Angeles to Chicago the same morning. The air was exceptionally clear as he cruised at 37,000 feet altitude. Shortly before 8:30 UT, he noticed a strange object almost directly below Capella that he soon recognized as a comet.

About 10:00 UT on July 24th, airline pilot Donald J. Duncan of Dallas, Texas, was flying over Arizona when he first saw the comet. He reported that the tail extended 12 or 15 degrees.

As if to save the credit of professional astronomers, independent discoveries of Comet 1961d were made at two American observatories that morning.

In Texas, a student observer at McDonald Observatory noted the celestial visitor. William B. Hubbard, Jr., was working with the 10-inch photographic refractor, taking plates of galactic clusters in search of Cepheid variable stars. With him during the night were two friends from Odessa, Texas, Mark Rader and Kenneth Short. At about 10:00 UT, Mr. Hubbard watched the passage of the Echo satellite across the sky from west to east. As it sank in the east, he noted the comet's tail protruding above the edge of Mount Locke. His two friends hurried to the top of the mountain for a better view, and returned to report that it was indeed a comet.

At 10:50 he took a photograph of the new object, using a 5-inch camera that is on the same mounting as the 10-inch. Mr. Hubbard then ran over to the dome of the 36-inch reflector where Dr. G. Van Biesbroeck was measuring double stars, to alert him, but on returning found the sky was too bright for a second picture. With this article is a photograph Mr. Hubbard took the following morning with the 10-inch telescope.

On July 24th Armin J. Deutsch saw the comet from Palomar Observatory. He reports: "At about 3:45 a.m. Pacific standard time, I took a turn around the catwalk while the night assistant was guiding the 200-inch telescope for my

The comet's coma and inner tail show well in this 1.4-times enlargement of a six-minute exposure started at 10:52 UT on July 25th, by William Hubbard, Jr., with the 10-inch Cooke camera at McDonald Observatory. The antitail extends down from the head.

last coude spectrogram of the night. I was surprised to see below Capella a narrow shaft of pale light standing almost perpendicular to the horizon. At first I thought the object was a searchlight beam, but it didn't quite reach the horizon. Auroral streamer? Vapor trail? No, it seemed fixed among the stars. It was a fine big comet!

"The comet's head was near Tau Geminorum. Dawn was too far advanced by this time to find the object with the 200-inch telescope, let alone get a direct photograph or a spectrogram.

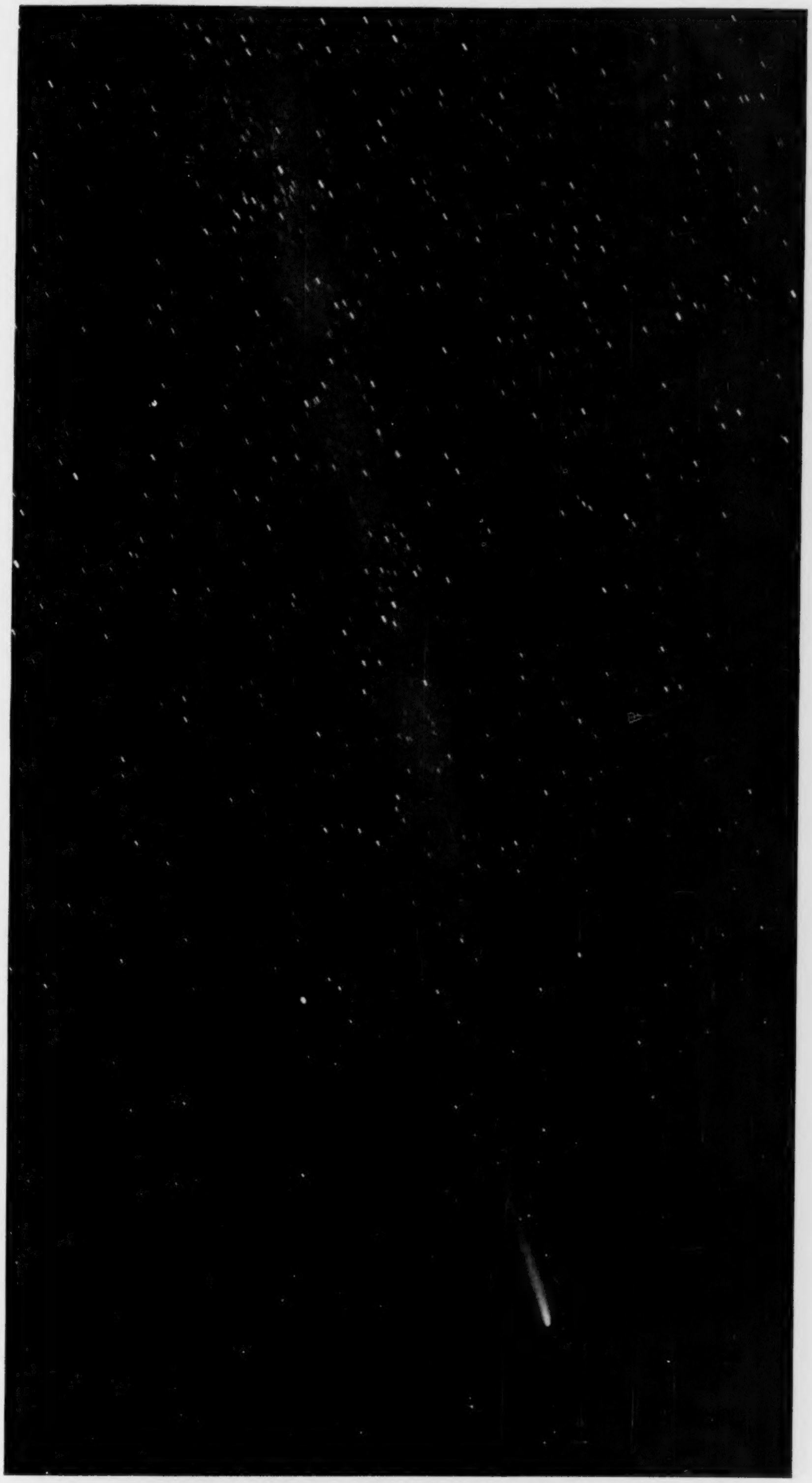
"It is no simple matter to pick up an object at the coude focus when the coordinates are unknown. At any one setting of the instrument, the eyepiece may be moved over a field of only about five minutes of arc, with only a one-minute area visible at a time. Moreover, the 200-inch is one telescope where there is no sighting along the tube: when it is pointed near to the horizon, no part of the 'tube' comes closer to the observing floor than 20 feet. There was no time to bring into use the wide-field finder at the prime-focus cage before the comet was swallowed up in the dawn.

"After moonset the following morning there was a magnificent view of the rising tail. It grew to a length of 25 degrees, and as the dawn progressed, the comet's head finally rose. At the 48-inch Schmidt camera, Byron Hill and I centered the nucleus in the finder, and read the right ascension and declination off the dials. I raced back to the 200-inch dome, where the night assistant had the telescope ready for me at its limiting hour angle of about seven hours east. There remained time only for me to set on the comet's head and obtain a single five-minute spectrogram.

"While I was with Hill at the 48-inch Schmidt, the night assistant watched from the 200-inch catwalk. The spectacle of the great comet rising tail-first left him somewhat less excited than it did me. He had seen the tail on several occasions during the last few nights, he explained, but had assumed it to be a searchlight!"

By July 25th, many observers had been alerted that a fine new comet was in the morning sky. Alan McClure of Los Angeles, California, took several photographs with his 7-inch f/7 photographic telescope on Mount Pinos (see front cover).

With the naked eye, the main tail was estimated as 20 degrees long, but it could be traced to 23 degrees in 12 x 70 binoculars. In addition, a faint antitail pointing *toward* the sun was recorded. On Mr. McClure's photographs it appeared about $3\frac{1}{3}$ degrees long, curving toward the north, but its visual extent in the binoculars was roughly 1.8 degrees. The total magnitude of the comet was carefully estimated as 3.2.



The main tail of Comet Wilson extends about 15 degrees, then out the top of the field in this nine-minute photograph by Alan McClure, which he began at 11:10 UT July 25th. Compare this with the cover picture, taken with the same 7-inch f/7 Fecker triplet camera. Here the tail's right edge is sharp, while the left fades into a widespread milky glow.

As the comet moved northward and westward from Gemini into Auriga during the next few nights, many other amateurs obtained views of it. At Grand Rapids, Michigan, John Wesley and Robert Moler observed it visually and secured a photograph with a 5-inch f/3.6 Schmidt camera on the morning of July 26th. At the time, Comet Wilson was

about half a degree south of Theta Geminorum.

Dennis Milon and other Houston, Texas, amateur astronomers made observations on three consecutive mornings, beginning on July 26th, when the tail was judged to be 20 degrees long and 1½ wide. The following night, despite the full moon, the total magnitude was estimated as 3½ by Robert Farmer, who could trace five degrees of tail. On the 28th, Mr. Milon examined the head with a power of 84 on his 8-inch reflector, noting an 8th-magnitude starlike nucleus.

Two members of the San Fernando Valley Astronomical Society, Lester Bergquist and Jack Harvey, photographed Comet Wilson on July 26th from Mount Pinos, where Mr. McClure had observed. On the original negative of their picture reproduced on page 124, the main tail extends 27 degrees. In addition to the antitail, two degrees long, there was a third tail, faint and narrow, northward of the principal one.

Mr. McClure's continued observations from Mount Pinos showed that the comet was fading, the total visual magnitude being 3.2 on July 26th and 4.8 on August 1st. On the latter date, the main tail was 12 degrees in length on a photograph taken with an f/2 Xenon lens of 5-inch focus. In 12 x 70 binoculars it seemed only half this long. The same photograph indicated nearly three degrees extent for the antitail.

Meanwhile, at observatories around the world, professional astronomers were determining accurate positions of Comet Wilson, the earliest being by Mr. Hubbard at McDonald Observatory and by Y. Tomita at Kyoto Observatory in Japan. It is not possible to compute the orbit of a newly discovered comet until three precise positions are available.

Using observations made in late July, F. M. Stienon of Harvard Observatory and M. P. Candy in England derived approximate orbital elements. Both computers assumed that the comet's path around the sun is a parabola. The nearest approach of Comet Wilson to the sun occurred on July 13th, according to Mr. Candy, and on the 17th, according to Mr. Stienon. At perihelion, when theoretically the object should have been even brighter than at discovery, it was nearly in line with the sun, on the near side, and therefore unobservable. The orbit of the comet is inclined about 20 degrees to the ecliptic, with the ascending node near the perihelion point.

Mr. Candy has published an ephemeris extending to August 19th, when the predicted co-ordinates were $5^h\ 23^m.9$, $+49°\ 55'$ (epoch 1961), a little north of Capella. On that date, the right ascension was decreasing 2.8 minutes of time per day, the declination increasing by 29 minutes of arc. Comet Wilson is fading rapidly, but in early September may still be visible with limited optical aid.

NEWS NOTES

POSITIONS OF FEATURES ON MARS

Cartography of the surface of the planet Mars is complicated by the great number of delicate markings, all of them more or less subject to change, whose positions are generally uncertain. Gerard de Vaucouleurs of the University of Texas has stressed the desirability of constructing a geometrically precise Martian map, in which the latitudes and longitudes of key points are accurate to 0.1 degree or better. This corresponds to four miles.

A first step in this direction was completed by Dr. de Vaucouleurs while at Harvard Observatory, in collaboration with Roy Wright. This was the collection of all available measurements of the co-ordinates of Martian surface markings made in the years 1909 to 1954. During this period, 21 different observers in many countries had measured the longitudes and latitudes of 586 points on Mars. Some of these 12,000 measurements were on photographs, others on drawings, while the remainder of the positions were obtained with micrometers and from timings of central-meridian transits.

A critical summary of these sources of areographic co-ordinates has been published by Dr. de Vaucouleurs and Mr. Wright as an Air Force scientific report.

MICROMETEORITE LAYER

Meteoric dust particles appear to be far more abundant in the earth's upper atmosphere than has been hitherto believed, according to R. K. Soberman, Air Force Cambridge Research Laboratories. He reports that a nose cone launched on June 6th from White Sands, New Mexico, recorded an unexpectedly high density of micrometeorites – about 10 struck each square centimeter of the detecting surface every second.

The nose cone was a podlike arrangement of individual leaves or petals covered with micrometeorite detectors. At an altitude of 47 miles the leaves opened, remaining exposed while the rocket rose to 102 miles and then began its descent. At 65 miles the petals closed, after being open about four minutes.

One type of detector consisted of two mylar sheets, ¼-mil and one-mil thick, backed by a ⅛-inch sheet of plexiglass. After the nose cone was recovered, examination of the microscopic holes in the mylar and of pits in the plexiglass (many were also visible to the naked eye) yielded information about sizes and motions of the particles, some of which had speeds up to 47 miles per second. Other detectors consisted of relatively thick films of three plastics of varying hardness – Millipore, Formvar, and lucite.

Although most micrometeorites vaporized on contact with the detecting surfaces, some were collected intact. Of particular interest are the residual bits of material left in the plastic. These will be analyzed in great detail by chemical, radioactive, and physical techniques. Inch-square sections of the detectors are available for study by qualified scientists.

Dr. Soberman suggests that the micrometeorite layer is formed by electrostatic trapping. Further studies are planned to ascertain the exact altitude at which the particles are concentrated.

NEW HARVARD RADIO TELESCOPE

Harvard University's radio astronomy field station at Fort Davis, Texas, is the site of a new 85-foot radio telescope scheduled for completion near the end of this year. Manufactured by Blaw-Knox Co. of Pittsburgh, the solid-surface antenna will be used primarily for research on radio waves from the sun's atmosphere.

The steerable equatorial mounting will permit observing objects from the north celestial pole to the southern horizon. Surface accuracy will be great enough for reception of wave lengths as short as three centimeters. The 110-foot-high structure is designed to withstand winds at velocities up to 120 miles an hour.

ANIARA

One of the very few operas to have a subject closely related to astronomy is *Aniara*, whose score was written by the contemporary Swedish composer Karl-Birger Blomdahl, with a libretto by Erik Lindegren.

The opera is the imaginative story of a great spaceship carrying hundreds of people toward Mars, but which deviates from its course and continues out of control endlessly into space. *Aniara* deals illuminatingly with the psychological transition of the passengers from their initial confidence in man's technology to final helpless extinction.

First performed at the 1959 Edinburgh festival, *Aniara* is now available in this country as a Columbia recording, the album containing a printed translation of the Swedish libretto.

IN THE CURRENT JOURNALS

STAR CLUSTERS WITH VARIABLE STARS, by Helen Sawyer Hogg, *Leaflet* No. 385, Astronomical Society of the Pacific, July, 1961. "Of 121 clusters currently listed as globular, more than 80 have now been searched for variables, and in them 1612 variable stars have been found and certain data concerning their light changes derived and published. The clusters early considered to be the richest in variables are still the leaders; Messier 3 has 189, Omega Centauri 165, and Messier 5 and 15 have about 100 each."

Variable Star Spectroscopist

MARGARET W. MAYALL

American Association of Variable Star Observers

IN 1919, a young astronomer who had joined the staff of Mount Wilson Observatory wrote the director of Harvard Observatory to ask for identification charts of some long-period variables. In addition, he requested predicted magnitudes for a number of variables on certain nights when he would be making spectroscopic observations with the Mount Wilson telescopes. He was furnished with predictions based upon observations received from members of the American Association of Variable Star Observers. Thus began many years of close contact and mutual help between Paul W. Merrill and the amateur astronomer.

Dr. Merrill wrote to Leon Campbell in 1920: "I had an opportunity this time to check up the predictions and found that in nearly every case they fell very close to the actual magnitudes as observed at the time. Thus they form a very good basis for making out the observing program for the spectrographs. I enclose my magnitude observations made on March 3 and 6. . . . If agreeable to you I should like to have this arrangement continued for several months." The several months became four decades of correlating the visual light curves with spectroscopic observations.

The death of Dr. Merrill on July 19, 1961, closed the career of one of America's foremost observational astronomers. Born in Minneapolis, Minnesota, in 1887, he received his astronomical training at the University of California. After working at the University of Michigan and at the National Bureau of Standards, he became a staff member of Mount Wilson in 1919, and remained there until his retirement in 1952.

Paul W. Merrill (third from left) was one of the hosts at the 1948 joint meeting of the American Astronomical Society and the Astronomical Society of the Pacific. With him here are (left to right) Otto Struve, C. M. Huffer, and Donald H. Menzel. A part of the 200-inch telescope mounting is in the background.

At the Stockholm meeting of the International Astronomical Union in 1938, Dr. Merrill (left) talks with the Dutch astronomer J. H. Oort.

His lifework was the observation of stars with peculiar spectra, and especially long-period variable stars. The great complexity of these spectra, and the remarkable changes they undergo, had a special fascination for him. Dr. Merrill's well-known popular book, *The Nature of Variable Stars,* appeared in 1938, and was followed two years later by his technical monograph, *Spectra of Long Period Variables.*

About 30 years ago, when fast photographic emulsions sensitive to infrared light first became available, he made a pioneer study of stellar spectra in previously inaccessible wave-length regions. Dr. Merrill paid much attention to the puzzling early-type stars that have bright spectrum lines, and with Miss C. G. Burwell published a valuable *Catalogue of Be Stars* in 1933, with a supplement in 1943.

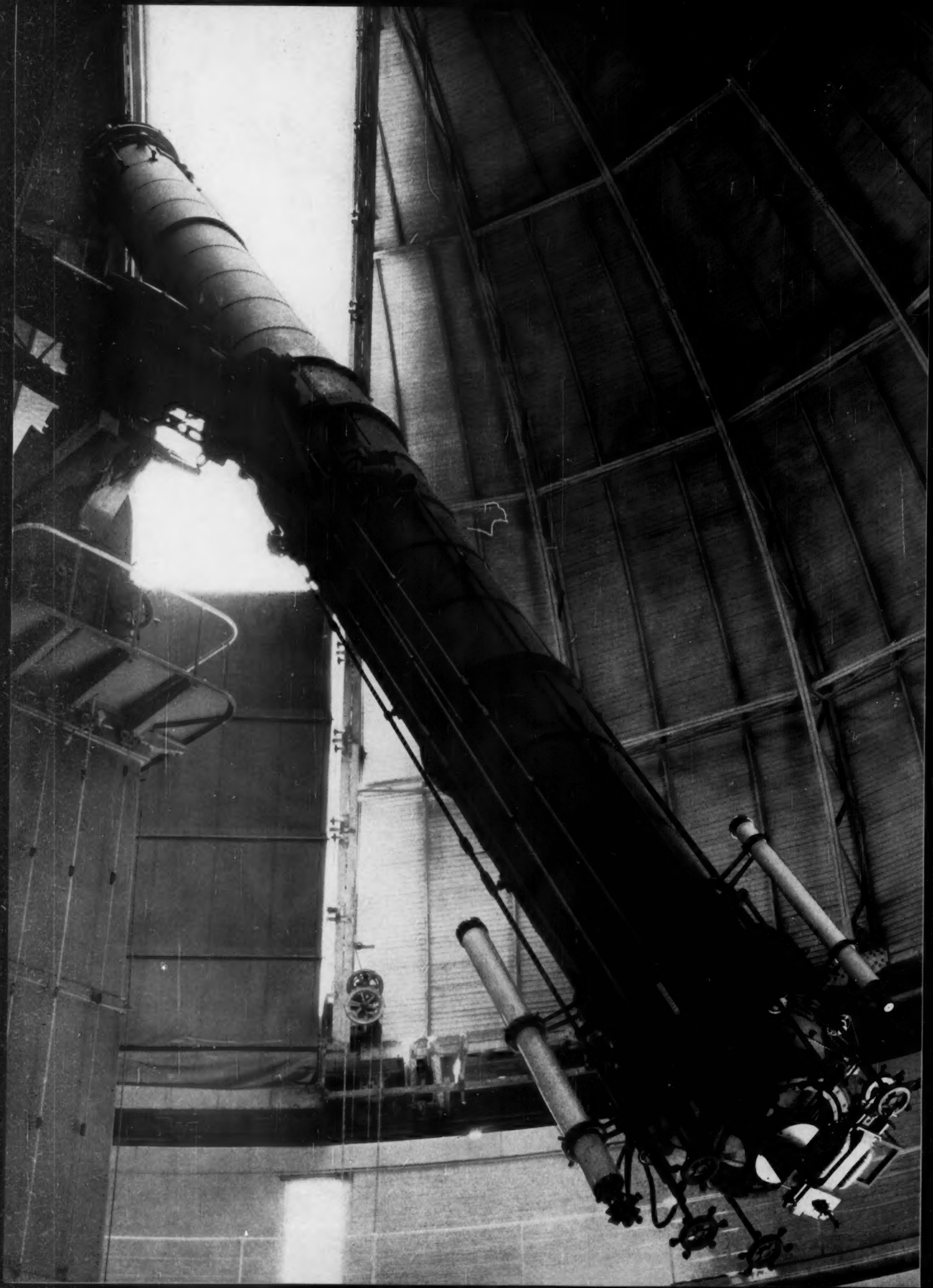
Perhaps the most significant single discovery he made was his 1952 finding of lines of technetium in the spectra of R Andromedae and several other *S*-type stars. This radioactive element does not occur naturally on earth, but has been prepared artificially. The longest half-life for any of its isotopes is less than a million years. The existence of so unstable an element in quantities large enough to produce observable spectrum lines is believed to mean that nuclear reactions are proceeding in the atmospheres of the cool, red *S* stars.

Dr. Merrill's great energy as an observer is made plain by the very large number of his papers in the *Astrophysical Journal* and the *Publications* of the Astronomical Society of the Pacific, dealing with peculiar spectra he had been studying. The long-period variable R Aquarii proved to be one of his most captivating problems. In 1919 he found nebular lines in its spectrum, and indications that the red star had a very blue companion, both variables being involved in nebulosity. Later, he questioned whether R Aquarii is actually double, and applied the expressive term "symbiotic" to the phenomenon. Patches of luminous gas were found far out from the central star, receding from it with velocities much greater than the velocity of escape. This behavior suggests that R Aquarii may have been a nova several hundred years ago.

Another symbiotic star intensively studied by the Mount Wilson astronomer was AG Pegasi. He summarized its peculiar spectral changes in an article that appeared in SKY AND TELESCOPE for July, 1959.

Dr. Merrill was always a friend to amateur astronomers, believing that their efforts could be of great value to science. Several years ago, he was asked to evaluate the work of the AAVSO. He wrote: "Detailed and continuous light-curves of long-period variables are essential if we are going to understand the physical operation of these marvelous objects. Average periods and mean light-curves are not enough. Secular changes such as those now known in R Hydrae and R Aquilae must be looked for carefully. In the future there should be more photometric work, not less. It goes without saying that accuracy should be increased if possible. Should not the AAVSO take an interest in helping the more serious and capable amateurs to adopt photoelectric observations?" He was very pleased when he later saw the work of several AAVSO members who had built photoelectric photometers and were using them successfully.

Many honors came to Dr. Merrill, including the Draper medal of the National Academy of Sciences, and the Bruce medal of the Astronomical Society of the Pacific. He was president of the American Astronomical Society from 1956 to 1958.



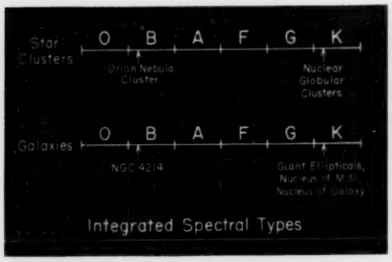
AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 108th meeting of the American Astronomical Society at Nantucket, Massachusetts, June 18-21, 1961. Technical abstracts will appear in the Astronomical Journal.

Classification of Galaxies

The world's largest refracting telescope, the 40-inch at Yerkes Observatory, has been used effectively for photography of galaxies as part of a classification program being carried on by W. W. Morgan, who gave the Henry Norris Russell lecture on this subject. Noted for his work on the spectral classification of stars, he has recently been applying similar techniques to exterior stellar systems.

First he noted the long-continued usefulness of the famous Hubble sequence, set up a quarter century ago. In this simple scheme, elliptical systems of increasing apparent flatness blend into two series of spirals, normal and barred, the most open spirals being at the opposite end of the sequence from the roundest ellipticals.



Drawing a parallel between the stellar contents of certain star clusters and galaxies, Dr. Morgan used this lantern slide to illustrate the extreme spectral types in his classification scheme (shown below at the right).

Some years ago H. Shapley suggested that the actual evolutionary progression might be in the reverse direction, and in Dr. Morgan's scheme, sketched here, the spirals provide the great bulk of objects between loosely knit irregulars on the one hand and highly concentrated ellipticals on the other. Central condensation is expressed as 1 for the least concentration to 7 for the strongest.

The labels indicate major population differences among the types, based on each system's integrated light, which gives a composite spectrum of a multitude of stars of different classes. Those contributing the most light dominate the spectrum, even if they do not constitute most of a system's mass. Can these stars be identified unambiguously and thus used to place galaxies in the classification system?

Dr. Morgan attacked this problem with the aid of the now universally adopted Morgan-Keenan-Kellman classification of stellar spectra (SKY AND TELESCOPE, May, 1953, page 184). In it the Draper classes, *O, B, A, F, G, K, M,* are broken down into luminosity groups, I indicating a supergiant star of greatest luminosity and V a dwarf, faintest in its class. Detailed criteria are given, such as relative line strengths, to permit astronomers working with modest equipment to assign spectral classifications to stars they are studying.

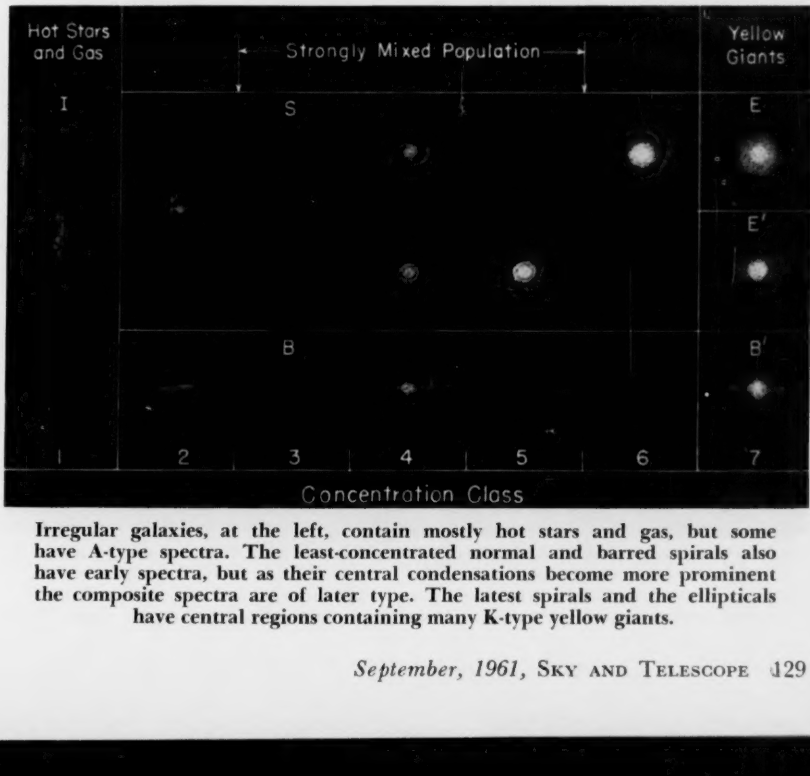
Galaxies are more difficult to observe spectroscopically, only the nearest ones being resolvable into stars and groups of stars. The classification system must apply to the generally more distant objects for which only composite spectra can be obtained. Dr. Morgan has found criteria for establishing a gradual sequence from irregular galaxies, which contain hot young stars and gas, through spirals with mixed populations, to ellipticals, which present chiefly late-type spectra.

Among the earliest irregular systems is NGC 4214, which has a spectrum resembling that of the Orion nebula star cluster. The continuous spectrum is strong far into the ultraviolet, and the nebular emission lines of ionized oxygen are also observed. Other irregulars of this kind are NGC 3991 and 6052, all rich in young stars of type *B*. Somewhat later spectral types are exemplified by NGC 4490, an irregular whose spectrum resembles the Pleiades cluster taken as a whole, average type *A*.

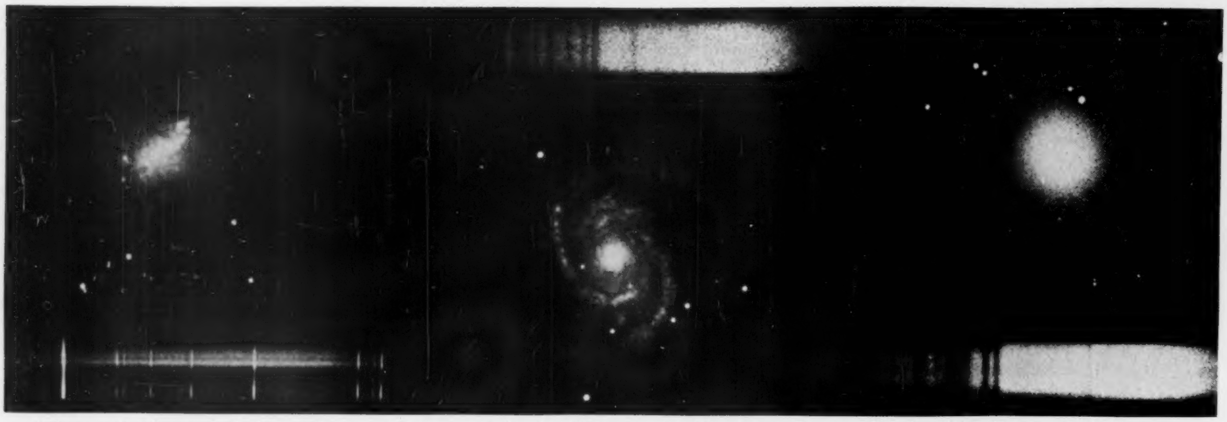
The spirals have varying characteristics, but are generally a mixture of types. Such objects as M100 (NGC 4321) possess spectroscopic compositeness to an extreme

W. W. Morgan, director of Yerkes Observatory, delivering the Russell lecture at the Nantucket meeting.

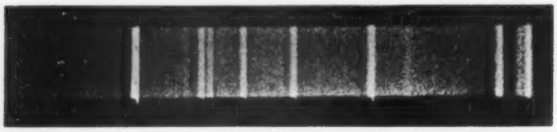
FACING PICTURE: The latest portrait of the 40-inch refractor at Yerkes Observatory, taken by Joseph W. Tapscott on July 3, 1961. Its Clark lens was made nearly 70 years ago. Famous for its work on double stars and in measuring stellar distances, the 40-inch has recently been adapted to many newer problems. Attached to the eye end in this view is an image-tube device, and on page 130 is pictured a reducing camera for work on galaxies. The giant objective has a focal length of 63 feet, requiring the observatory dome to be 90 feet in diameter. Yerkes Observatory photograph.



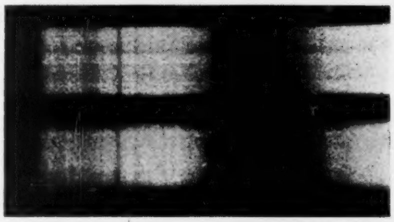
Irregular galaxies, at the left, contain mostly hot stars and gas, but some have A-type spectra. The least-concentrated normal and barred spirals also have early spectra, but as their central condensations become more prominent the composite spectra are of later type. The latest spirals and the ellipticals have central regions containing many K-type yellow giants.



These galaxies and their spectra represent types in the Morgan classification scheme. At the left, NGC 4214 is an irregular of extremely early type, showing hydrogen, helium, and ionized oxygen emission lines. In the center is NGC 4321, having moderate central concentration and a highly composite spectrum. At the right is a strongly concentrated elliptical system, NGC 4374, with a K-type spectrum dominated by yellow giant stars. The direct photographs were taken with the Yerkes 40-inch refractor by Robert Garrison; the spectra were obtained with the McDonald 82-inch reflector.



Compare this spectrum of the Orion nebula (near the Trapezium) with that of the irregular galaxy NGC 4214, above left.

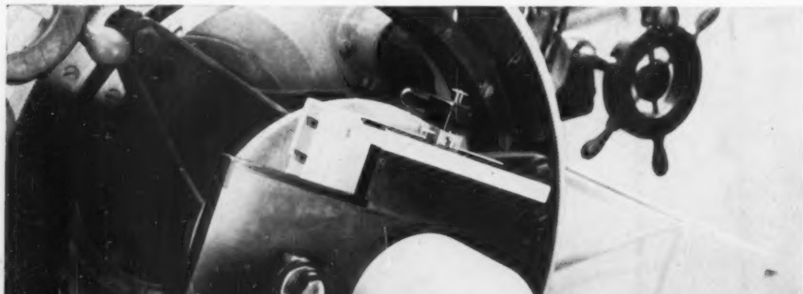


The upper spectrum, of the K0 giant star Delta Tauri, is strikingly similar to that of the central portion of M31 (lower spectrum). Absorption features of the compound CN are found in both cases, clearly proving that yellow giants are present in M31, as these absorptions are not observable in dwarf stars. Toward the right in these spectra, taken at Lick Observatory, a broad region of weakening has resulted from insensitivity of the plate emulsion at certain wave lengths.

degree, seeming to consist of both young and old populations of stars.

Some spirals, such as M31 in Andromeda, have central regions dominated by yellow *K*-type giants, resembling in this respect many globular clusters in our own Milky Way galaxy. The giant elliptical systems, including NGC 4374 in Virgo (M84), have in the violet rather pure *K*-type spectra, in which the absence of stars of the early spectral types *(B, A, F)* is pronounced.

As mentioned above, Dr. Morgan and his associates have used the 40-inch refractor for some of this work. Its normal focal ratio, f/19, makes it far too slow for photography of most galaxies. However, a reducing camera was constructed by A. B. Meinel, whereby the long-focus telescope can be made as fast as f/3. A field lens is placed at the focal plane of the 40-inch objective so that all the light from a large field will pass through a "collimator" lens that is followed closely by a filter and a "camera" lens. The size of the photographed image depends on the ratio of the collimator- and camera-lens focal lengths, and the over-all speed of the telescope is increased by this same factor. The camera lens can be changed, a 2-inch focal length being used to make the 40-inch instrument f/3, a 3-inch for f/4.5, and a 4-inch for f/6.



For the Yerkes 40-inch refractor, a breadboard model of a reducing camera was built and found to work well. The present camera, shown here attached to the telescope, is of completely new design (sponsored by the U. S. Air Force), but with some of the original Meinel optics. Yerkes Observatory photo.

At Yerkes, Robert Garrison has used such equipment to secure photographs suitable for classification work on galaxies. His 30-minute exposures were made on Eastman 103a-D emulsion with a Schott GG-11 filter. Dr. Morgan illustrated many of his points with these pictures.

The second part of the Russell lecture concerned the relative compositions of clusters of galaxies, particularly the Ursa Major and Virgo clusters. In general, the latter has more member galaxies of high concentration (late type) than the former, and this characteristic has been found for some other clusters. Do these differences indicate evolutionary changes in galaxies? Dr. Morgan concluded by asking, suggestively, "Is our present epoch unique

for observing these systems? If we were to look at the rich clusters of galaxies at some time in the distant past, there is evidence that they would have a systematically different aspect from the way they appear now."

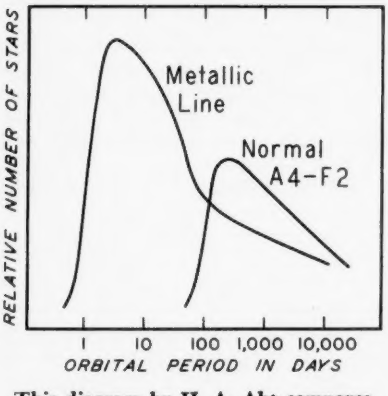
Polarization of Galactic Radio Noise

The diffuse background of radio noise originating from the Milky Way contains a plane-polarized component, reported C. L. Seeger of the Stanford Radio Astronomy Institute. His work was done jointly with G. Westerhout of Leiden Observatory.

This discovery resulted from exploratory observations made with the 25-meter radio telescope at Dwingeloo, Netherlands. With this instrument, in which a phase-switch polarimeter was installed, measurements were made at a frequency of 408 megacycles per second in various regions of the sky above, in, and below the galactic plane. In addition, observations were secured along the great spur of radio emission that extends northward from near the galactic center.

The two radio astronomers took extensive precautions in order to ensure as far as possible that the polarization they were observing was real and not of instrumental origin. For example, check observations were made on different nights at different hour angles. Special all-night measurements of the region of the north pole were taken to assess the instrumental polarization.

The importance of the polarization of the Milky Way radio noise is that it affords direct evidence of interstellar magnetic fields. The plane of polarization was fairly constant over some regions 10 degrees or more in extent, as along the spur. This uniformity may mean either that the interstellar magnetic field is constant in direction over large parts of the galaxy or that the polarized radiation originates relatively near the sun. Even though a quantitative interpretation is



This diagram by H. A. Abt compares the number of binary systems (relative to the total number of stars) among normal and metallic-line A-type stars, showing that the latter tend to have much longer periods.

difficult, Drs. Seeger and Westerhout believe that a general program of mapping the magnetic fields in the galaxy is possible with present-day techniques.

Radio Source 3C-48

Last December Allan R. Sandage, Mount Wilson and Palomar Observatories, described optical and radio observations of a 16th-magnitude object in Triangulum that could possibly be the first case of a true radio star (see the March issue, page 148). Harlan J. Smith and Dorrit Hoffleit and their students at Yale Observatory have checked the location of radio source 3C-48 on all photographs in the Harvard Observatory collection that contain this region of the sky.

Of some 2,500 plates, most penetrated below 11th magnitude, 600 reached 13th, less than 100 as faint as 15th, and only 75 showed an image of the 3C-48 object. Between 1895 and 1952, no year had fewer than nine plates, the average being around 40. Thus, if a full nova or supernova explosion had occurred at any time in that interval, it could scarcely have escaped detection. Since 1898 the 16th-magnitude image showed no variation greater than ±0.2 magnitude.

Despite the absence of light changes, the apparent size of a faint nebulous shell around the star and Doppler broadening of the shell's spectral lines suggest that 3C-48 is indeed an exploded object. The Yale astronomers feel that all available data are consistent with the remnant of a type-I supernova similar to that which generated the Crab nebula, intrinsically several times fainter, about six times farther away (7,000 parsecs), and only one-fifth as old, perhaps occurring some two centuries ago.

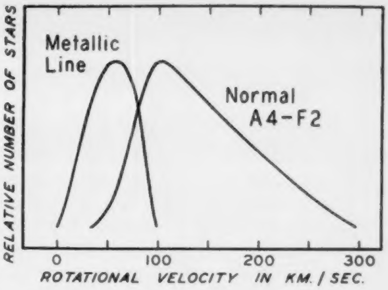
In presenting this paper, Dr. Smith noted that a bright "guest star" was reported in Chinese records as occurring 280 years ago in this part of the sky, although the position and description of the object are vague.

Binary Frequencies Among A-type Stars

At the society's Pittsburgh meeting last year Helmut A. Abt, Kitt Peak National Observatory, proposed that all metallic-line stars (spectral type *A*m) are actually binaries (SKY AND TELESCOPE, July, 1960, page 24). The question then arises as to what percentage of normal *A* stars are physical pairs.

In search of an answer, Dr. Abt has studied spectra of 57 dwarf and subgiant stars of spectral types *A*4 to *F*2 taken with the 82-inch McDonald coude and 60-inch Mount Wilson Cassegrainian spectrographs. In a preliminary report, he noted that complete measurement of 24 of the stars yielded nine spectroscopic binaries – indicating duplicity of at least 35 per cent of normal *A* stars.

However, all nine binaries have periods greater than 100 days; in addition, none



The rather clear-cut distinction between rapidly rotating Am stars and more slowly rotating normal stars is shown here. Both diagrams are courtesy Kitt Peak National Observatory.

of the remaining 33 incompletely measured cases show the large radial-velocity variations to be expected from short-period binaries. Therefore it appears probable that all stars of this type that are members of binary systems with periods less than 100 days are *A*m objects, while the single stars have normal spectra. This is shown in the chart at left below.

The metallic-line spectra may be related to the duplicity through the latter's effect upon the stars' rotational velocity. As indicated in the chart above, there are no rapidly rotating *A*m stars and no slowly rotating normal *A* stars. Perhaps rapid rotation inhibits the magnetic fields that produce the extended atmospheres which, in turn, may account for the peculiar spectra.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is the gegenschein?

A. Gegenschein is a German word meaning "counterglow"; the phenomenon is a faint patch of light some 10 degrees in diameter in the night sky directly opposite the sun. To see the gegenschein, an extremely clear, moonless sky is needed, far from any artificial lights.

Q. Where is Pulkovo Observatory?

A. This famous Russian observatory is located on a hilltop 12 miles south of Leningrad. Opened in 1839, it achieved early fame for precise star positions, double star studies, and stellar spectroscopy.

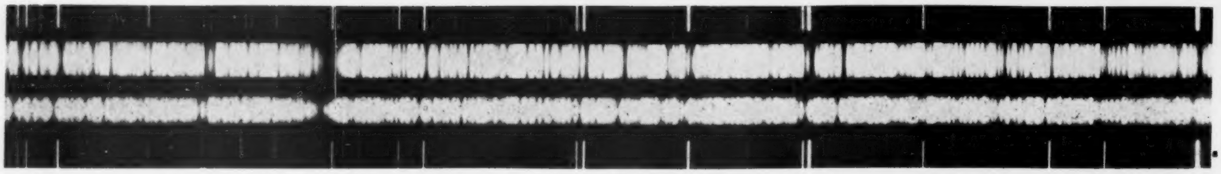
Q. What are the speeds of Jupiter's four bright satellites in their orbits?

A. The mean speed of Io around Jupiter is 10.8 miles per second; Europa, 8.5; Ganymede, 6.8; and Callisto, 5.1.

Q. Which star is nearer, Proxima or Alpha Centauri?

A. Their distances are very nearly the same, but Proxima Centauri is perhaps nearer. There is strong evidence that it is a member of the Alpha Centauri system, making the latter a triple star. No other star closer to the sun is known.

W. E. S.



Two spectra of the blue region, 4200 to 4300 angstroms, of the K-type giant star Arcturus. The upper spectrum, taken on July 1, 1939, has lines displaced redward, indicating recession at 18 kilometers per second. In the lower spectrum, taken January 19, 1940, a marked shift toward the violet shows a 32-kilometer-per-second approach velocity. The difference of 50 kilometers per second is due to the earth's orbital motion, but the average velocity indicates approach. Mount Wilson and Palomar Observatories photograph.

Stellar Radial Velocities and Their Observation

Otto Struve, *National Radio Astronomy Observatory**

CHRISTIAN DOPPLER at the University of Prague described in 1842 how the approach or recession of a light source would affect its spectrum. The analogous effect of motion upon the pitch of a sound wave was already known; the whistle of a locomotive as it comes toward the listener seems higher than when it recedes.

Doppler concluded that the spectrum of an approaching light source should be displaced toward the violet (shorter wave lengths), while a receding source would show a redward shift. In the case of a star, there would be an over-all reddening if the distance between Earth and star were increasing, or added blueness if it were decreasing.

From a practical standpoint, however, no such over-all color effect may be expected for stars belonging to the Milky Way, where the relative velocities are never larger than a few hundred kilometers per second. In 1848 the French physicist and astronomer L. Fizeau pointed out that the Doppler shift could actually be seen only in the displacements of the absorption and emission lines of a star's spectrum. It is these shifts that we seek to measure in determining stellar radial velocities – the speeds at which stars are moving along our line of sight.

The Doppler effect can be expressed as a simple proportion:

$$\frac{\text{Radial velocity}}{\text{Speed of light}} = \frac{\text{Wave length change}}{\text{Wave length}}.$$

Consider a star coming toward us at 50 kilometers per second, about 1/6,000 the speed of light, which is roughly 300,000 kilometers per second. If the star has the familiar yellow D pair of sodium lines in its spectrum, not far from 6000 angstroms wave length, they will be shifted toward the violet by nearly one angstrom. The accompanying spectra of Arcturus illustrate an equivalent change in radial velocity in the blue region of the spectrum, where the spectral shift is about two-thirds as great as in the yellow.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

Christian Doppler (1803-53) taught at Prague and Vienna. He wrote voluminously on optics, acoustics, and especially mathematics.

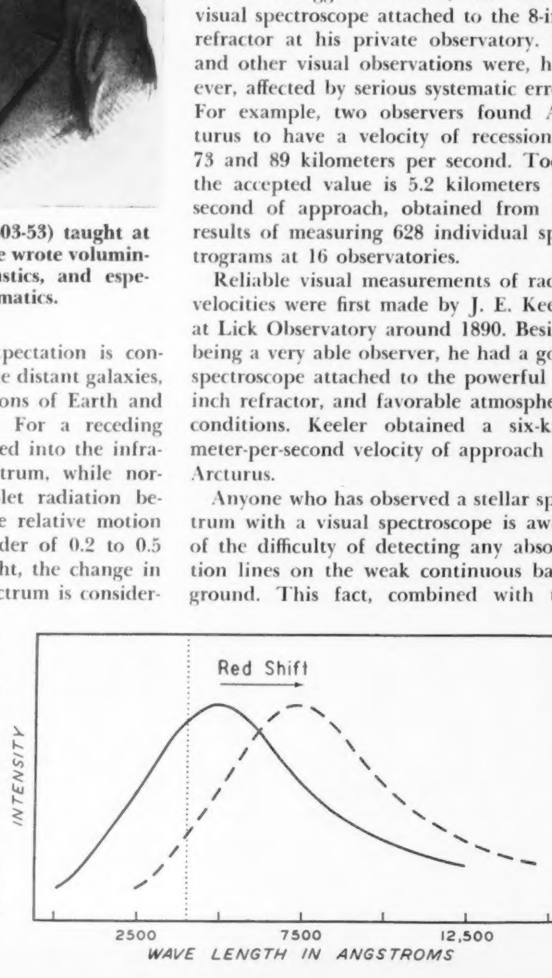
Doppler's broader expectation is confirmed when we study the distant galaxies, where the relative motions of Earth and sources are very large. For a receding galaxy, red light is shifted into the infrared region of the spectrum, while normally invisible ultraviolet radiation becomes visible. When the relative motion is very large, of the order of 0.2 to 0.5 times the velocity of light, the change in the character of the spectrum is considerable, as shown by the diagram. At Mount Wilson and Palomar Observatories, W. A. Baum has made extensive measurements of the energy distributions of distant, rapidly receding galaxies whose normal spectra would resemble the sun's. Their observed spectra, however, exhibit striking shifts of their entire energy curves toward longer wave lengths.

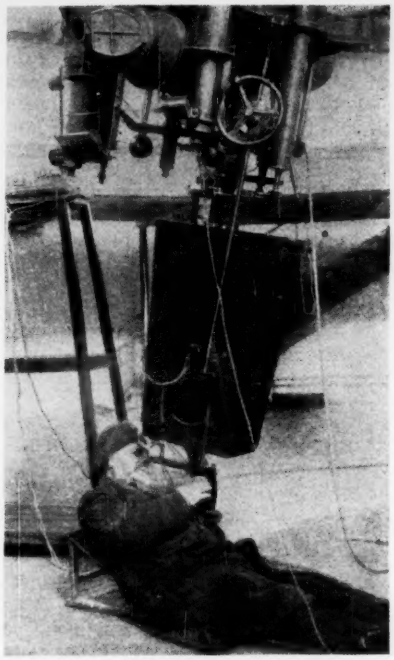
The first practical application of the Doppler principle was attempted by Sir William Huggins in 1868, who used a visual spectroscope attached to the 8-inch refractor at his private observatory. His and other visual observations were, however, affected by serious systematic errors. For example, two observers found Arcturus to have a velocity of recession of 73 and 89 kilometers per second. Today the accepted value is 5.2 kilometers per second of approach, obtained from the results of measuring 628 individual spectrograms at 16 observatories.

Reliable visual measurements of radial velocities were first made by J. E. Keeler at Lick Observatory around 1890. Besides being a very able observer, he had a good spectroscope attached to the powerful 36-inch refractor, and favorable atmospheric conditions. Keeler obtained a six-kilometer-per-second velocity of approach for Arcturus.

Anyone who has observed a stellar spectrum with a visual spectroscope is aware of the difficulty of detecting any absorption lines on the weak continuous background. This fact, combined with the

This chart shows two spectral-intensity curves for a typical galaxy. The solid line applies if the galaxy is at rest relative to Earth, the dashed line if receding from us at half the velocity of light. Such a rapidly moving object would appear markedly reddened. Dotted ordinate is wave length of maximum sensitivity of ordinary photographic plates.





A. A. Belopolsky (1854-1934) at the spectrograph of Pulkovo Observatory's 30-inch refractor.

task of producing in the spectroscope a comparison spectrum from a terrestrial source, makes it surprising that radial velocities of even a few stars were determined by Keeler and others with a fair degree of precision.

In 1863, Huggins had attempted to photograph stellar spectra with wet plates, and in 1872 Henry Draper obtained a wet-plate spectrogram of Vega showing four absorption lines. After dry plates became available, both Huggins and Draper used them successfully.

But measurements of these early spectra were affected by serious errors, and it is therefore appropriate to consider the years 1888-91 and the work of H. C. Vogel and J. Scheiner at Potsdam as the real beginning of the era of radial velocity determinations. Their average probable error was only 2.6 kilometers per second, a 10-times improvement over earlier results. Vogel attracted a number of astronomers to Potsdam, where they learned his techniques. Among them were E. B. Frost, who continued his radial velocity work at Yerkes Observatory, and A. A. Belopolsky, who returned to Pulkovo Observatory and remained active in this field for 25 years. At Lick Observatory measurements of high accuracy were started by W. W. Campbell. He constructed the famous three-prism Mills spectrograph that has, with minor improvements, served several generations of astronomers.

By the end of the 19th century, Huggins commented on the future of radial velocity determinations: "This method of work will doubtless be very prominent in the astronomy of the near future, and to it probably we shall have to look for the more important discoveries in sidereal astronomy which will be made during the coming century." In the early 1900's, this application of the Doppler effect was so promising and rewarding that those who had access to large telescopes were very enthusiastic. I recall that Frost often said he would rather measure stellar radial velocities than engage in any other type of scientific activity. Much of the glamor of such work has disappeared in more recent years, and astronomers now often regard it as a necessary but unexciting occupation.

Radial velocities of single stars and spectroscopic binaries are listed in a 1953 catalogue by R. E. Wilson, published by the Carnegie Institution of Washington. It contains results for 15,107 stars. Wilson investigated the systematic differences among the principal observatories contributing data for the catalogue, adopting the Lick Observatory system as his standard. The differences depend to some extent upon the spectral type of each star, being caused in part by discrepancies in the wave lengths adopted for the absorption lines. For Mount Wilson, which furnished almost half of the entire material, the systematic corrections are zero for spectral type *A*, +0.5 kilometer per second for classes *F* and *G*, and −0.5 for *K* and *M*.

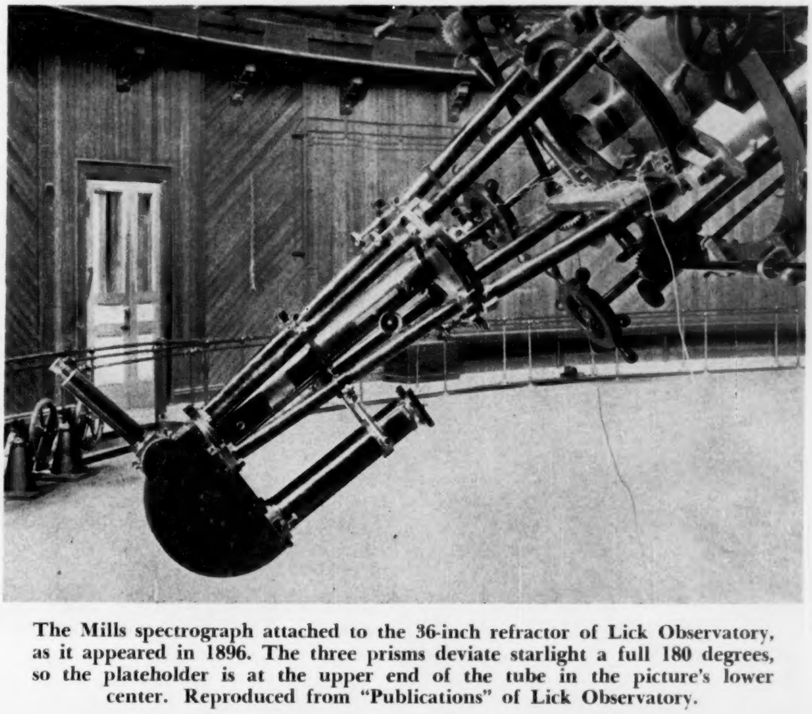
It is difficult to ascertain how many stellar spectrograms have been taken for radial velocity measurements since 1900. Wilson's values for single stars represent the means of four or five spectrograms, but for spectroscopic binaries several hundred spectra were occasionally needed to establish the line-of-sight velocity of an individual system's center of gravity. It is probably a reasonable inference that the total number of spectrograms is roughly 200,000.

Radial velocities have great statistical significance. Long ago we detected a correlation between mean radial velocity and spectral type: the *B* stars have slower motions than main-sequence *K* and *M* stars, while those of type *O* occasionally have large values. Though originally attributed to the equipartition of energy among stars of different masses, this phenomenon has more recently been considered to indicate stellar motions in orbits around the center of the galaxy.

Of special interest are the movements of the members of clusters and associations. The nearby moving cluster of the Hyades has been studied for many years, and its members' radial velocities are known with high accuracy from the work of J. A. Pearce at Victoria, British Columbia. Some workers believe that stellar associations are expanding with speeds of the order of 10 kilometers per second, but this view is not accepted by all spectroscopists, and there is need for additional observations.

A word should be said about the measurement of radial velocities of many stars on a single plate obtained with an objective prism. The most successful method is that of C. Fehrenbach and his coworkers at Haute Provence Observatory (SKY AND TELESCOPE, July, 1961, page 9). Their procedure depends essentially on relative displacements of lines recorded with two different orientations of the objective prism, and the precision is comparable to that of slit spectrographs with small dispersions.

Radio astronomers also apply the Dop-



The Mills spectrograph attached to the 36-inch refractor of Lick Observatory, as it appeared in 1896. The three prisms deviate starlight a full 180 degrees, so the plateholder is at the upper end of the tube in the picture's lower center. Reproduced from "Publications" of Lick Observatory.

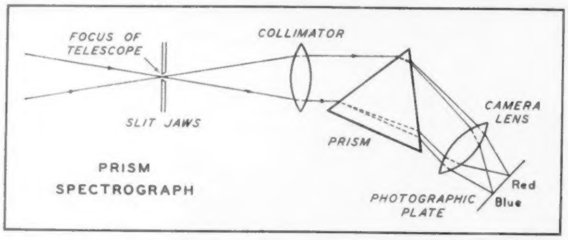
pler principle. The formula shows that the measured displacement of a spectral line is twice as large at 7500 angstroms in the deep red as it is at 3750 in the ultraviolet. Thus, it is advantageous to measure Doppler shifts at long wave lengths. However, most photographic plates are more contrasty and sensitive in violet than in red light, and most radial velocity work has been done at short wave lengths. On the other hand, with sensitive receivers at the long waves of the radio spectrum, it is now possible to obtain radial velocities of interstellar hydrogen gas clouds with a precision at least 10 times that of optical observations.

When photographing the image of a star, it is customary to widen the spectrum by trailing the image along a part of the spectograph slit. The comparison spectrum is put on either side of the star's by two prisms, one at each end of the slit. Light from an iron arc or a titanium spark is projected parallel to the plane of the slit and then reflected into it by the prisms. This method was described to the American Astronomical Society by Lick's W. H. Wright in 1900.

All of the early stellar spectroscopists – Vogel, Campbell, Frost, Belopolsky, F. Küstner at Bonn, and somewhat later J. S. Plaskett at Ottawa and Victoria – employed glass prisms as their dispersing units and doublet lenses for the collimators and cameras. They soon realized that in order to conserve light the collimator should be made as long as possible, its aperture large, while the cameras should have shorter focal lengths. Typical ratios of collimator-to-camera lengths were about two or three to one, but in recent years several spectrographs have been constructed with this ratio as large as 10 or more.

When the ratio is one, the optical system produces on the photographic plate a monochromatic image of the slit whose width is equal to that of the slit. Hence, the earlier spectrographs employed slit widths of the order of 0.01 to 0.03 millimeter, but even in very good seeing the image of a star in the focal plane of a large telescope may be about one second of arc in diameter. In the case of the Yerkes 40-inch refractor, for example, this would correspond to 0.1 millimeter, many times the width of the slit in an early spectrograph. Much of the light was wasted because it never got through the slit.

In a prism spectrograph, diverging light from the slit is made parallel by the collimator, and then allowed to pass through a prism. Blue light is deviated more than red, creating a spectrum that can be recorded on a photographic plate.



This picture of E. B. Frost (left), A. A. Belopolsky, and F. Ellerman in 1899 shows the elaborate terra-cotta columns that adorn the north and south entrances of the Yerkes Observatory. Most of the figures on the left column represent signs of the zodiac. But there are two human faces interspersed at intervals, one of which appears at the top of the photograph, and the other just above Frost's left shoulder. No one knew why the architect had included them until it was suggested that the broad, smiling face belonged to President W. R. Harper of the University of Chicago – after Mr. Yerkes (represented by the lean, unhappy-looking profile) had given the university the money for the observatory's construction.

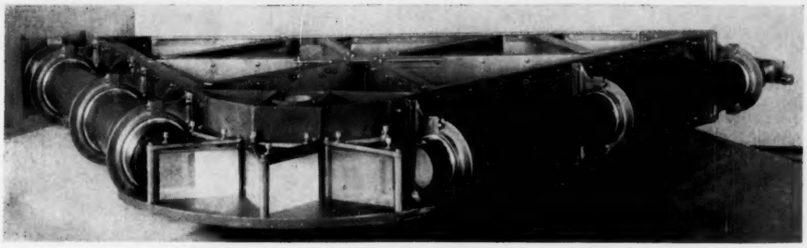
Since the width of the slit image (or spectral line) is inversely proportional to the collimator-to-camera ratio, the larger ratios of later instruments permit the use of wider slits while still producing narrow spectral lines. Modern slit apertures of several tenths of a millimeter utilize much more of the incident starlight and reduce exposure times correspondingly.

Probably all stellar spectroscopists have meditated on the feasibility of using the light intercepted by the jaws of the slit. The only constructive idea for doing this was published by I. S. Bowen in 1938. His "image slicer" consists of a series of thin glass plates or mirrors which displace strips of the original star image, lining them up on both sides of the principal image. This procedure produces a series of narrow spectra, and to some extent obviates widening the spectrum by trailing the star image along the slit. However, no method exists, and Bowen says that none can be invented, that would enable the observer to superpose the slices on top of the narrow spectrum produced by the central strip.

Opening the slit involves a new source of error, investigated by Plaskett a quarter century ago. If the image of the star is not accurately centered on the slit, a spurious shift of the spectral lines takes place. In most parts of the sky, atmospheric dispersion causes an image to be slightly blue on one side and red on the other. Since the yellow part of the image might be used for guiding, while the blue was dispersed and photographed, a positional error of the lines corresponding to a radial velocity of several kilometers per second might occur.

This problem becomes especially serious when the dispersing unit is a quartz prism or a diffraction grating used for obtaining ultraviolet spectrograms. D. M. Popper has found that in the McDonald Observatory's Cassegrainian spectrograph the ultraviolet star image may actually be completely off the slit at zenith distances of 50 degrees or more, due to atmospheric dispersion. Occasional guiding errors, however, allow the ultraviolet to enter the slit from time to time, producing an underexposed spectrogram.

Such an effect is less serious in poor seeing, although it is then difficult to focus the stellar image accurately. In exceptionally poor seeing, a star image at the Cassegrainian focus of the 82-inch reflector may be nearly one centimeter in diameter. Incorrect focusing on the slit causes non-



A three-prism spectrograph of typical design is shown with its constant-temperature jacket removed. The slit and collimator appear at right, the camera at left. Three prisms are used to obtain greater dispersion.

uniform illumination of the collimator and the dispersing unit, which is another source of error, because no such nonuniformity exists in the comparison spectrum.

A major difficulty recognized by all the early spectroscopists is flexure of the spectrograph when attached to the moving telescope. Great care has been taken to avoid such an effect, but the only satisfactory solution is to use a stationary spectrograph at the telescope's coude focus. But since the coude field rotates, while the slit remains fixed, guiding along the slit usually must be done in two co-ordinates except when the star is on the meridian. At the McDonald Observatory, a slow drive in declination was built into the telescope so that the observer could automatically correct for changes in this co-ordinate while guiding in right ascension. At Mount Wilson and Palomar Observatories an auxiliary "image rotator" is placed in front of the slit.

Slippage of Cassegrainian optical parts as the telescope's orientation changes during an exposure has never been adequately investigated. To avoid deformation, each optical part may move within its supporting frame by as much as 0.1 millimeter. If the slippage occurs uniformly, the spectrum lines appear broadened, but if it takes place at irregular intervals, the lines may appear double or multiple. Although for high-dispersion observations such effects may be avoided by using coude spectrographs, work at small and medium dispersions is often done at either the prime or Cassegrainian focus. There are practical advantages in having the observer on the observing floor, where he sees both the telescope and the spectrograph.

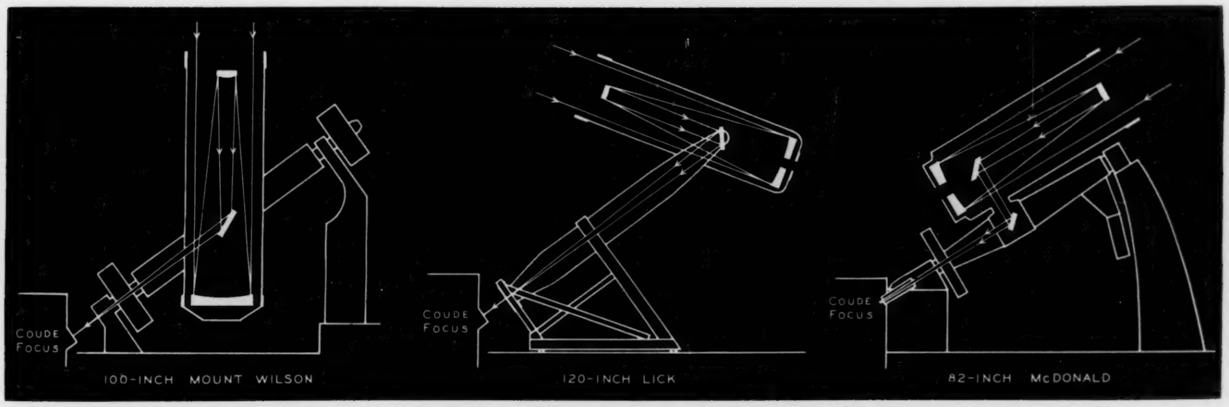
Campbell and others recognized that the characteristics of prisms and mechanical parts change with temperature during an exposure, causing additional line displacements. Hence it became customary to control the spectrograph's temperature thermostatically, but in some cases the result was illusory, because the thermostat was turned on only half an hour before the astronomer started his work. Actually, even small spectrographs take several hours to adjust to a surrounding constant temperature. The observer felt safe, when he should have suspected difficulties.

I vividly remember some spectrographic work on the binary star Pi Scorpii carried out simultaneously by C. T. Elvey and me. He had a new spectrograph (not designed by him) at Dearborn Observatory of Northwestern University, and I used the Bruce spectrograph at Yerkes. We often obtained spectrograms at the same hour of the same night, but the Dearborn results departed markedly from mine – in some cases by as much as 100 kilometers per second. Accidentally, Elvey found that good agreement was obtained when he did not use his thermostat, and later he discovered that the thermostat controlled a stream of warm air which blew against one of the principal members of the spectrograph frame. When the heater was on, the whole instrument bent, so an erroneous radial velocity was obtained if the comparison spectrum happened to be exposed while the thermostat had the hot air turned off.

In the 1920's and 30's, W. S. Adams and his associates at Mount Wilson attempted to control the 100-inch coude spectrograph to better than 0.1° centigrade. But the enormous mass of iron and cement that constitutes such a large spectrograph varies little with outside temperature. Thus, it has been found that better results may be secured without thermostatic control. On an average night the temperature inside the spectrograph drops less than one degree in 12 hours.

With a modern coude spectrograph having a dispersion of three angstroms per millimeter, Adams has derived radial velocities of Arcturus that are probably accurate to 0.01 kilometer per second. Even this precision could be improved if a stellar spectrograph were always used in the same form, as a modern meridian circle is. Instead, spectrograph cameras and dispersing units are changed at frequent intervals, so collimation and other adjustments cannot be maintained as perfectly as they would be if the whole instrument were kept intact.

In a large reflector, additional sources of error arise from the mirror system. The beam of starlight from the Mount Wilson 100-inch mirror falls on a hyperbolic secondary which increases the effective focal length. At the intersection of the optical and polar axes, an elliptical plane mirror reflects the beam into the hollow polar axis, where it comes to a focus on the spectrograph slit. At declinations greater than about +30°, however, the projected image of the elliptical mirror becomes smaller in declination, than in right ascension. At about +51° its projected width is essentially zero and no light reaches the spectrograph. Evidently, there is a wide difference in collimator illumination among stars of different declinations, and also between starlight and the comparison source.



The path of starlight (indicated by the arrows) to the coude foci of three large reflectors is shown by these sketches. The 100-inch telescope has a two-pier mounting, and the 120-inch is mounted in a fork. The McDonald cross-axis mounting requires two coude mirrors, but they are always at 45-degree angles to the telescope's optical axis.

Convention at Detroit

NORMAN C. DALKE

Seattle Amateur Astronomical Society

Photographs and drawings by members of the Association of Lunar and Planetary Observers are examined by (left) Carl Fielding, Seattle, and John Campbell, Denver.

DURING the Fourth of July weekend in Detroit, Michigan, the thermometer rose into the 90's every day of the Astronomical League's 15th general convention. However, the heat did not depress the spirits of well over 200 delegates from various corners of the country meeting as guests of the Detroit Astronomical Society.

Saturday morning's general session included a business meeting, at which the executive secretary reported a continually increasing public interest in astronomy throughout the United States and Canada. As of this June, the league's membership had grown to 139 regular member societies, 28 junior ones, 40 members at large, two affiliate and 13 supporting organizations. The incumbent league officers were renominated, and subsequently re-elected at the Monday business session.

Memorials to two noted amateurs were read by vice-president Ralph Dakin. Clarence Johnson of Schenectady, New York, who was instrumental in setting up the league's junior astronomy program, died last October 24th. News had just been received of the death on June 27th of Beaufort Ragland, Richmond, Virginia, long the chairman of the Middle-East region.

Amateur telescope makers who would like to make their hobby a vocation now have this opportunity by registering with the newly formed AL Optical Placement Committee. A list of experienced optical workers among amateur astronomers is being compiled, and will be made available to the optical industry. It is hoped that the committee can help interested amateurs throughout the country locate suitable outlets for their talents.

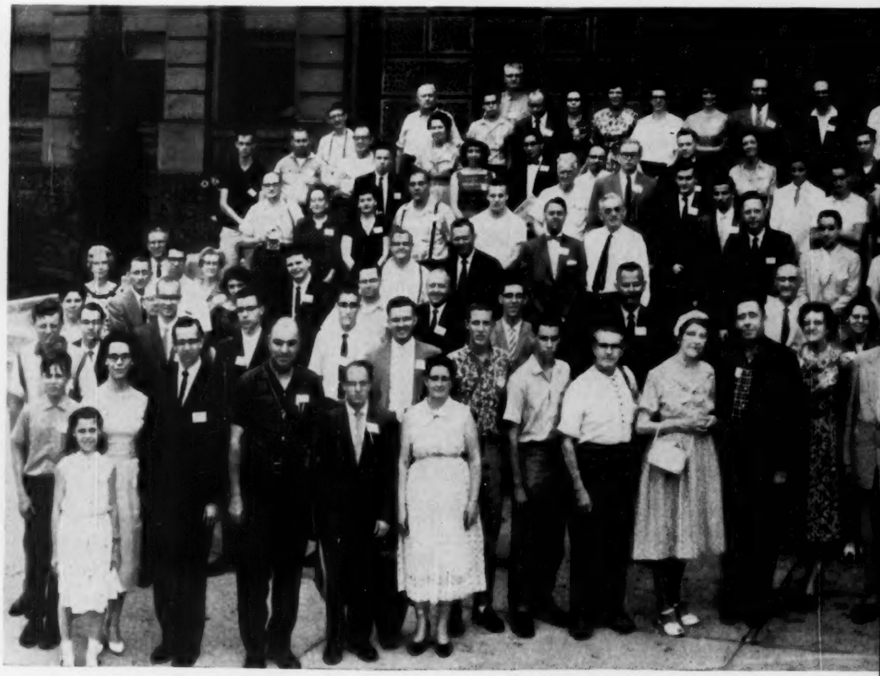
Material suggesting a study program in preparation for a professional career in optics will be sent to all those applying to the committee. There is no charge for the service, but a stamped self-addressed envelope must be enclosed with all inquiries. Applications may be obtained from Robert E. Cox, Chairman, Optical Placement Committee, 327 S. Main St., O'Fallon, Mo.

In preparation for Saturday afternoon's field trip to the Portage Lake observing station of the University of Michigan, Dr. William E. Howard lectured on radio telescopes. His discussion concluded with some of the specific studies being undertaken at Michigan. Four large buses plowed through the dust to the top of Peach Mountain and the radio astronomy station, delegates examining a 28-foot solar instrument, a now unused interferometer, and the 85-foot steerable reflector. About half a mile away, the university's 24-36-inch Schmidt telescope was also shown to the visitors.

Open for inspection Saturday evening were the headquarters and telescope workshop of the Detroit club. Unfortunately, skies were overcast and a proposed star party could not be held. But there were plenty of nonastronomical diversions, including 18,000 square dancers who had invaded the city for a weekend.

At the Association of Lunar and Planetary Observers meeting on Sunday, Walter H. Haas announced that the 12-page Jupiter observing manual by Elmer J. Reese, a helpful handbook for anyone interested in studying the giant planet, had just been published. The Mercury program at the Montreal Centre of the Royal Astronomical Society of Canada (RASC), comet observing, least-squares solutions for refining data, and color observations were among the topics discussed by ALPO members. James Mullaney and George Doschek expressed willingness to confirm any amateur work with the large telescopes of Allegheny Observatory in Pittsburgh.

A slightly different approach to amateur research in astronomy was described by Gary Wegner of Bothell, Washington. In an effort to assay the composition of the moon's surface, he compared his



The 15th annual convention of the Astronomical League.

Convention visitors to the 24-36-inch Curtis Schmidt telescope of the University of Michigan discuss stellar photography with astronomer Peter B. Boyce (right of center). Photograph by R. E. Cox.

Helen Sawyer Hogg of David Dunlap Observatory was the convention's principal speaker. She is noted for her work on variable stars in clusters.

lunar spectra with those for terrestrial mineral combinations.

Evidently amateurs everywhere have local conditions that prevent them from achieving optimum results at their telescopes, judging from the comments made by the speakers. Although during a Montreal winter Constantine Papacosmas must combat −50° F. temperatures and stay at least three inches from his eyepiece to prevent its fogging, he is not afflicted by the summer clouds of hungry mosquitoes that harass observers in coastal Texas.

The convention's major address was by Helen Sawyer Hogg, who spoke on "Astronomy in Canada Today." Since its inception in 1890, the RASC has grown until it now has 2,000 members – professional and amateur – all over the world. Most of its activities are concentrated in 16 observing centers across Canada from Halifax to Vancouver. Dr. Hogg went on to describe the various Canadian observatories and their instrumentation.

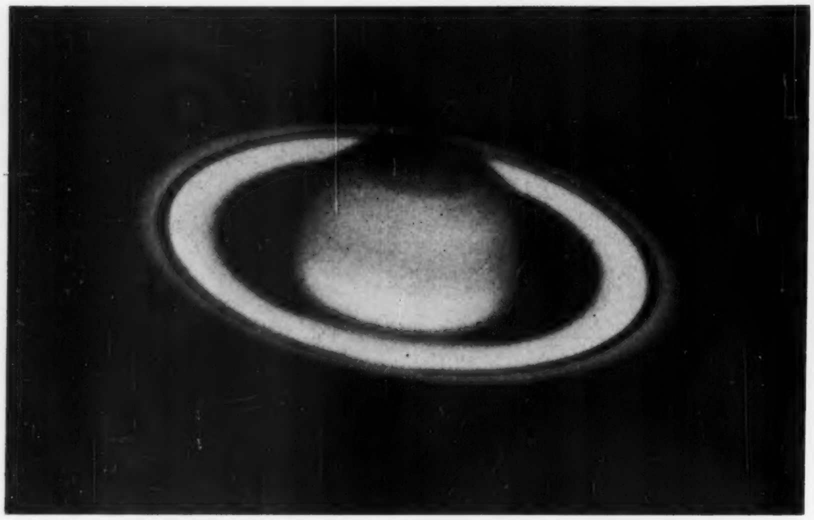
At the Sunday evening banquet, the ALPO award was presented to Clark Chapman of Buffalo, New York, for his contributions to planetary observing. As a change of pace from astronomy, the banquet speaker, Harvey Merker, former director of scientific relations at Parke Davis Co., told the history of medicine from the days of witchcraft to the present.

Monday's session began with a description of the Texas Astronomical Society's observatory and the difficulties of its construction. Problems in observing the gegenschein were outlined by Mr. Cox. The best time to look for the counterglow is during the winter months, just after midnight. But the sky must be especially clear, and the observer's eyes completely dark-adapted.

Other papers concerned such varied topics as teaching high-level astronomy to grammar school children and why an observer sees an enlarged image through a telescope, even though the instrument itself does not magnify. The session was brightened by nine-year-old Diana DeWald, who reported on moon rays.

Amateur astronomers from all over the United States convened in Detroit, Michigan, over the 4th of July weekend, 1961.

Getting Acquainted with Astronomy



Saturn as photographed on December 14, 1943, with the 36-inch refractor at Lick Observatory. At that time, the ring system appeared opened out to nearly the maximum possible extent, and the south pole was tipped toward the earth. Note the darkness of the south polar regions.

The Planets — Saturn – I

In 1610, when Galileo turned his primitive telescope toward Saturn – the outermost planet then known – he announced that it was triple, with a companion on each side of the main body and nearly touching it. Not until 1659 was the correct explanation found by Christiaan Huygens, the same man who discovered the planet's brightest moon, Titan.

He described Saturn as "surrounded by a thin, flat ring, nowhere touching the planet's body, and inclined to the ecliptic." Today, a 3-inch telescope shows clearly the general nature of the ring system, and most amateurs long remember their first views of this beautiful planet in a large instrument.

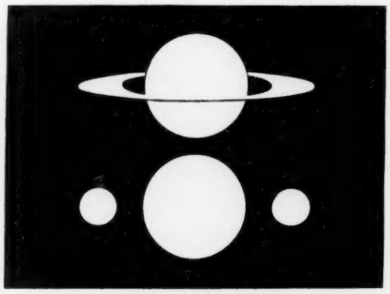
Saturn takes 29½ years to complete a revolution around the sun at an average distance from it of 887 million miles. But its orbit is distinctly elliptical, and when the planet was at aphelion on May 29, 1959, it was 936 million miles from the sun. This distance will lessen steadily until January, 1974, when Saturn reaches the perihelion point of its orbit.

As seen from the earth, a planet is in opposition when the sun is opposite to it in the sky. The synodic period is the interval from one opposition to the next, 378 days on the average for Saturn. In 1960, 1961, and 1962, its dates of opposition are July 7th, 19th, and 31st, respectively. Saturn makes its nearest approach to the earth, at a distance of 746 million miles, when it is simultaneously at opposition and perihelion.

Despite its remoteness, Saturn's large size makes it appear as bright as stars of magnitude 0 to +1. Second only to Jupiter in dimensions, Saturn's globe is about 66,400 miles in polar and 74,200 miles in equatorial diameter. It is thus more flattened at the poles than any other of the principal planets. The extreme diameter of the ring system is 171,000 miles, its plane coinciding with that of the planet's equator.

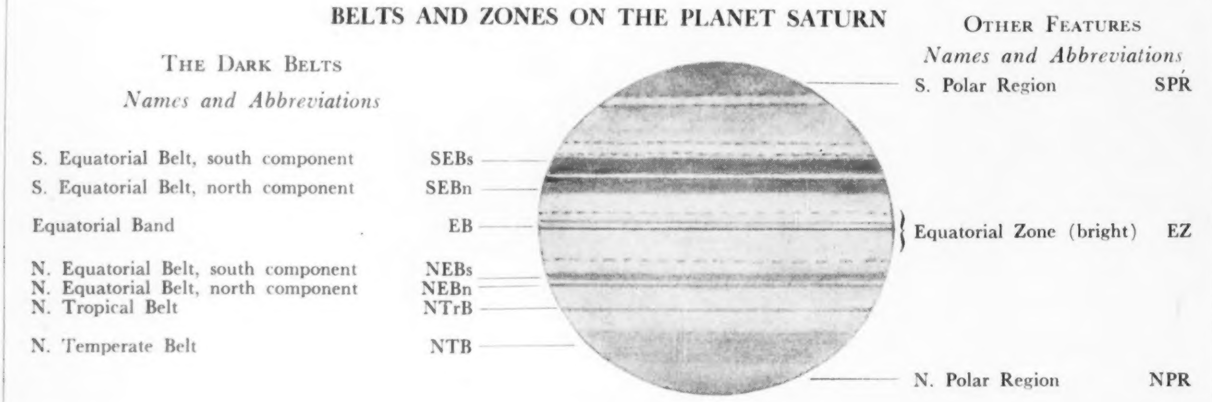
This month's account of Saturn deals primarily with the globe, leaving the rings and satellites for a later installment. The planet itself is physically very similar to Jupiter, being composed mainly of hydrogen and hydrogen compounds, having a low mean density (only 0.7 that of water in the case of Saturn) and very rapid axial rotation.

The resemblance to Jupiter also extends to telescopic appearance, many of the characteristic features of the giant planet being shared by Saturn, but less conspicuously. A 5-inch telescope is the smallest that can be of much service for studying Saturnian disk features. The most marked of these are the dusky South Equatorial Belt and the North Tropical Belt, the bright Equatorial Zone, and the darkish north and south polar regions. The diagram at the foot of the page shows the nomenclature of the principal permanent and semipermanent features.



The upper diagram indicates the actual aspect of Saturn and its rings in 1610, when Galileo first examined it telescopically. Beneath it is the Italian observer's interpretation of what he saw – a triple planet. Reproduced from "Splendour of the Heavens."

BELTS AND ZONES ON THE PLANET SATURN



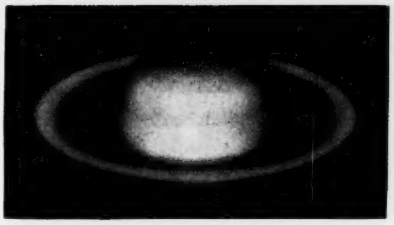
In 1940, E. C. Slipher at Lowell Observatory photographed Saturn in red, violet, and yellow-green light (left to right), in quick succession. Striking differences among the images show clearly that the planet's globe is much redder than the rings, but the equatorial zone is relatively blue. Amateurs can note these effects visually with color filters.

In addition, occasional markings visible in larger instruments include thin, streaky belts in high southern latitudes, and small white polar caps. All of these features are less well marked than those of Jupiter, and lack the rich colors often seen upon the latter.

By far the most important disk observations to be made are careful records of the rarely occurring spots. Central-meridian transits of Saturnian spots can be timed by the same method used by students of Jupiter, as explained on page 273 of the May issue. Such observations are greatly needed to evaluate the rotation period of Saturn. This period is shortest at the equator and lengthens toward the planet's poles.

A brilliant white equatorial spot was observed in 1876 by Asaph Hall (who next year discovered Mars' two moons). This gave a rotation period of 10 hours 14 minutes 24 seconds. Similar values were obtained from other short-lived equatorial white spots in 1891-94 and in 1933. The later feature, first detected by the British music-hall star and amateur astronomer Will Hay, was well observed in the United States, England, and Germany.

Spots in higher latitudes are very rare. In 1956, Henri Camichel of Pic du Midi Observatory, France, photographed a small white feature at latitude 12°.3 south that yielded a period of 10 hours 21.4 minutes. In 1903 a spot was seen in north latitude 36°, from which W. F. Denning deduced 10 hours 39 minutes 21.1 seconds.



H. Camichel photographed this temporary white spot near the center of Saturn's disk on February 11, 1946. Such spots are important for finding the rotation periods in different latitudes. From "Astronomie Populaire," by Camille Flammarion.

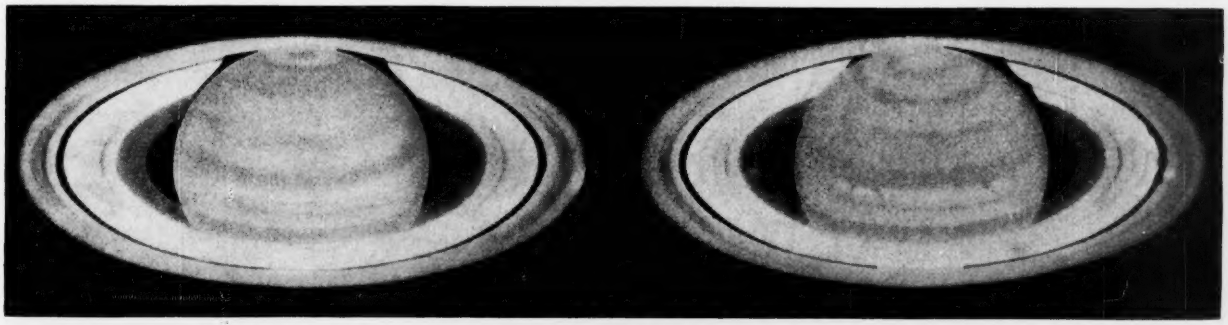
The most noteworthy event on Saturn in recent years was a great outburst of white spots in latitude 60° north. The first sightings, in late April, 1960, were by A. Dollfus in France and by J. H. Botham in South Africa. Members of the Association of Lunar and Planetary Observers made a concerted effort to secure as many central-meridian timings as possible. In all, they observed 11 spots, one lasting until September 20th. T. A. Cragg, from an analysis of their records, found the rotation period in that latitude to be 10 hours 39 minutes 52 seconds.

This result appears to disagree with the spectroscopic finding by J. H. Moore of Lick Observatory in 1939, who concluded that Saturn's rotation required an hour longer in latitude 57° than at the equator. Evidently only a beginning has been made at mapping the complex motions in the planet's atmosphere.

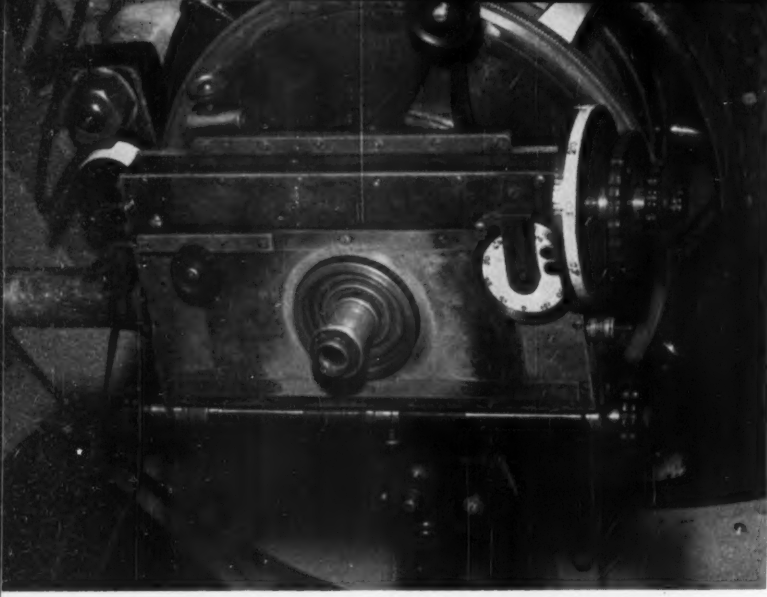
Currently many amateur observers of Saturn are making estimates of the relative intensities of various disk features, usually on a numerical scale of 0 to 10. Cragg reports on the basis of ALPO work in 1959 that the Equatorial Zone was the brightest part of the ball, and that the North Equatorial Belt was the darkest belt. In a similar study that year with the 18-inch refractor of Rio de Janeiro Observatory, the North Polar Region was estimated as practically equally dark.

The problem of changes in the relative intensities of disk features, both during the course of a single season and from year to year, should be an interesting project for amateurs with fairly large instruments.

(To be continued)



Among the best drawings of Saturn are those by the French observer G. Fournier. He made these two with a 20-inch refractor at Sétif, Algeria, on December 18, 1913, and February 15, 1914, left and right respectively. In the former, there is noteworthy detail in the polar region. Much structure can be seen in the ring system, and the ball of the planet is visible through the semitransparent innermost ring. The second picture shows a bright zone north of the equatorial belt, crossed by dusky lacings. Note the great breadth of Encke's division in the outer (A) ring, and the presence of irregularities in the rings, especially in the eastern half. Fournier often suspected that the inner (C) ring had a flocculent appearance. From "Observatoires Jarry-Desloges, Observations des Surfaces Planétaires."



The filar micrometer of Lick Observatory's 36-inch refractor.

The Construction of a Filar Micrometer

CHARLES E. WORLEY

Lick Observatory, University of California

ONE of the most useful accessories for a well-mounted telescope is a micrometer, for it allows the patient, practiced observer to make a substantial contribution by measuring visual double stars. Last month (page 73) we reviewed the history of this subject and emphasized the shortage of observations of close binaries.

The bifilar (two-wire) micrometer is a classical astronomical instrument that has been used for more than a century to make accurate measures of small angular distances on the celestial sphere. The heart of the device consists of two fine wires placed in the focal plane of the telescope, with provision for determining both the distance between the wires and their orientation. Of the many types of micrometers that have evolved over the years, the bifilar is still perhaps the most versatile.

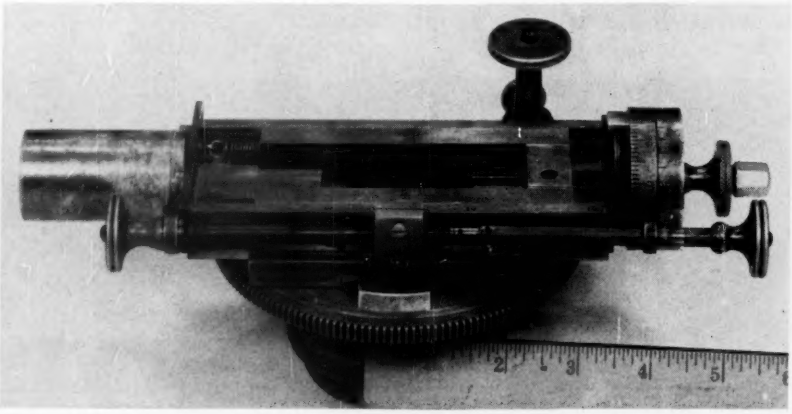
To realize its full potential, however, the instrument must be used with a suitable telescope. A very sturdy, carefully aligned equatorial mounting and an accurate clock drive are absolutely necessary. Further, a long focal length is desirable, to give a large scale to the field of view; for this reason, refractors are generally preferred to reflectors, but the latter can be used if they are well built.

Reproduced here is a close-up view of the micrometer attached to Lick Observatory's 36-inch refractor. One of the wires is fixed and the other movable by means of an accurately machined screw. The drum at the right and the long screw at the bottom are used to set the wires on the components of a double star and measure their separation. Both wires are held in a carriage so that together they may be turned through 360 degrees around the optical axis of the telescope until the fixed wire is superimposed upon both stars to indicate the position angle.

To illustrate the construction of such an instrument, we have chosen the compact and convenient, yet accurate micrometer of the 12-inch Lick refractor. The picture at left below is of the position-angle circle, which is divided into degrees and half-degrees, and may be read by estimation to 0.1 degree. The square plate is the base on which the micrometer box slides. This base is secured by a circular flange, invisible beneath the position-angle circle, which permits the box to rotate freely. The tapered pointers 180 degrees apart indicate the position angle on the circle when the box is rotated. This rotation is controlled by the large knob and pinion gear (upper left in the picture), which may be locked at any desired position by means of the small screw clamp.

In the third picture, the micrometer box is shown, secured to its base by two undercut metal strips, one of which is seen lying flush with the nearest (and only visible) edge of the base plate. Above this strip is centered the head or nut for the long tangent screw in the near side of the box, with a control knob at either end. With this screw the box may be moved left and right, carrying the eyepiece and both wires longitudinally across the field of view.

To the right is the micrometer screw, the most important unit in the entire instrument. The screw is held stationary in



Left: The position-angle circle of the Lick 12-inch refractor's filar micrometer. At the bottom (behind the ruler) appear the threads of the tube that fastens the micrometer to the telescope in place of the usual eyepiece holder. If a ring gear had been used for the circle, the need to machine teeth about the circumference would have been avoided.

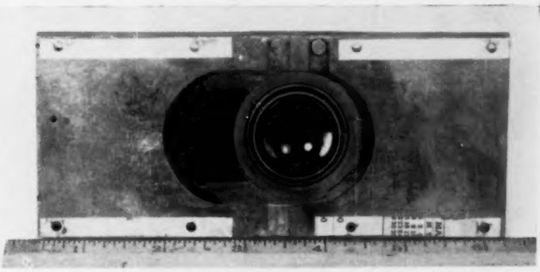
Right: To the position-angle circle and base-plate assembly of the previous picture has been added the movable micrometer box, including the micrometer head and screw for shifting the movable wire, which is not installed here. At the right are two drums, the inner counting hundredths of a revolution of the screw, the outer counting whole turns.

the box, and turning it causes the central U-shaped brass assembly to move. The two long arms are hollow and contain springs (partially visible at the left) that maintain proper tension. To eliminate backlash when a measure is taken, the screw is always turned against the spring tension. In any bifilar micrometer, the screw should be at least one inch long and have 40 to 80 threads per inch. It is convenient to have a drum reading in hundredths of a revolution, so that thousandths can be estimated. Combined micrometer heads and screws may be purchased at reasonable cost from such firms as Tubular Micrometer, Brown and Sharp, and Starrett.

It should be mentioned that in most commercially available micrometer units the head is held stationary and the screw moves. In such a case the springs must be attached to the side of the box nearest the drum. Instead of the U-shaped brass assembly, a rectangular piece should be used. The screw, pressing against a ball bearing set in this piece, and held tense by the reversed springs, will then provide the required motion equally well.

Near the mid-points of the long arms of the U may be seen grooves, into any pair of which the movable wire is glued, extending across the gap between the arms. For illuminating the wires, a light in the tube at the extreme left shines through a slit in the end of the box, its intensity controlled by a rheostat. The 12-inch micrometer could be improved by adding small, shielded bulbs to illuminate the drums and position-angle pointers while a reading is made.

The eyepiece unit, its lower side pictured here, is next attached to the micrometer box by means of eight screws. Note the grooves for fastening the fixed wire, one end of which is attached to a blunt screw. When the wire has been put in place, it can be adjusted parallel to the movable wire by very gently turning this screw. The fixed and movable wires must be as nearly in the same plane as possible, yet must not interfere with each other. Therefore, great care is necessary in spacing the eyepiece unit slightly above the moving-wire assembly. The picture shows the four paper spacers used for this purpose.

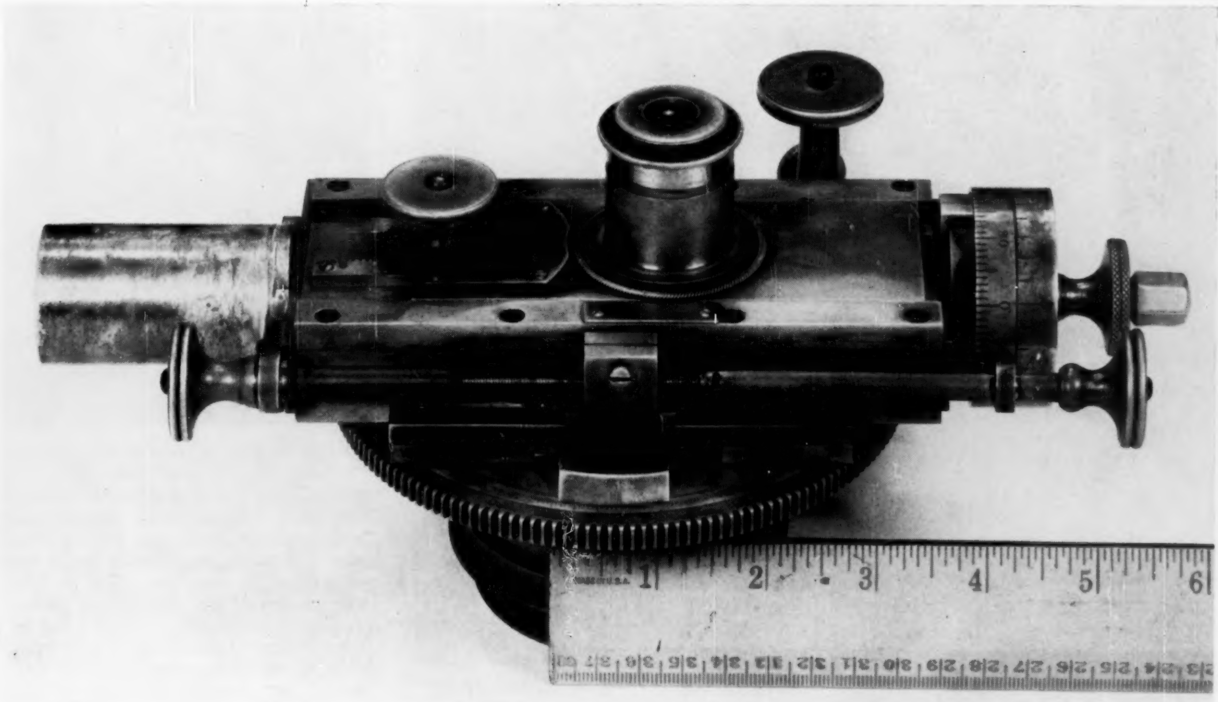


This unit attaches face down to the frame of the micrometer box. The oval slot shows the amount of movement of the eyepiece that is possible in order to center it over the wires. The fixed wire is not in place. All photographs from Lick Observatory.

In the past, micrometer wires have been obtained from spider webs or cocoons. If long, even strands can be obtained, this material is perfectly satisfactory. But modern technology provides a convenient, if expensive, substitute in the form of annealed tungsten wire of 0.0002-inch diameter, obtainable from Sigmund Cohn Manufacturing Co., Mount Vernon, New York. This wire is now used in the 12-inch micrometer, and has proved exceedingly satisfactory. It has great uniformity, high tensile strength, and is very easy to apply.

Micrometer wires may be installed by placing rosin or some other sticky material on the points of a pair of calipers. We attach one end of the wire to a point of the calipers, draw out a sufficient length of wire, and catch it on the other point. Then we spread the calipers gently until the wire is taut, and lay it across the grooves, cementing with a small amount of dilute glue. When the glue has set, the ends of the wire are carefully snipped free from the calipers and trimmed.

The final photograph shows the complete micrometer. The eyepiece unit is mounted in its own channel, with a rack and pinion at the left to provide for centering the eyepiece over the wires. Before the instrument can be used for double star measurements, however, the value of one revolution of the micrometer screw in seconds of arc must be determined, and the north point (zero) on the position-angle circle must be found. These operations and an example of a double star measure will be described in a subsequent article.



When all parts are assembled, the micrometer becomes a compact device easily attached to the telescope's tailpiece.

Meteor Photography with a Light Amplifier

GRADY T. HICKS

U. S. Naval Research Laboratory

IMAGE INTENSIFIERS have already proven their worth in astronomical photography by allowing shorter exposure times for faint objects. The Naval Research Laboratory's closed-circuit television system achieves this purpose, and in addition makes it possible to take moving pictures of meteors invisible to the unaided eye.

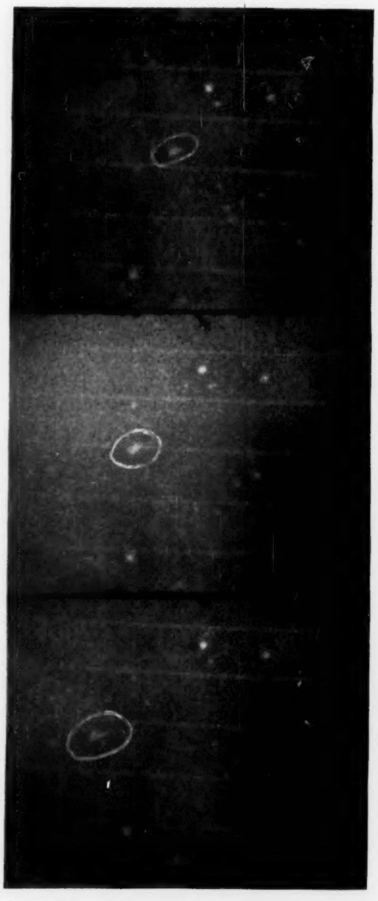
The two series of pictures, enlargements from 16-mm. motion-picture film, are views of the television monitor. They show meteors of magnitude approximately +5 to +7, considerably brighter than the limit of the equipment, which has recorded 9th-magnitude stars. These meteors are probably a few magnitudes fainter than super-Schmidt cameras have been able to photograph up to the present time.

The TV system consists of a Bendix Friez Lumicon camera, and an image-intensifier orthicon tube developed by RCA under contract with the armed services and designated C-73477. The multi-alkali surface of the C-73477 is about 1½ inches in diameter, and when used with a 4.8-inch lens of 12-inch focus gives a field of about seven degrees.

Our monitor uses a 10SP4 display tube. Vertical scanning is at the standard TV rate of 30 frames per second, each made up of two interlaced fields. An Auricon Super 1200 motion-picture camera loaded with Tri-X film was used to photograph the meteor flights that appeared on the monitor. Run at 24 frames per second, the camera gave 1/50 second exposure per frame.

The TV system was operated continuously from 3:00 to 5:00 a.m. on November 22, 1960, at Tilghman Island, Maryland. Various parts of the sky in the general direction of the ecliptic east of the meridian were viewed. The motion-picture camera was on at intervals during the two-hour period for a total of 70 minutes. In this time, 14 meteors were recorded on the film, averaging one meteor every five minutes. This is roughly the rate at which 6½-magnitude sporadic meteors would be expected to pass through the seven-degree field.

These preliminary results with the closed-circuit television system demonstrate the possibility of extending photography of meteors by several stellar magnitudes. Using lenses of greater light-gathering power to reach even fainter limits, with shorter focal lengths to increase the field of view, two systems observing the same portion of the sky from sites a few miles apart should yield useful quantitative data on meteors too faint to study with present optical techniques.



Successive frames from two series recording meteors on November 22, 1960. These photographs of pictures displayed on a standard 10-inch television picture tube are 1/24 second apart in time, progressing from top to bottom in each case. The meteors are encircled for easy identification. Imperfect electronic circuitry gave the stars a three-dimensional appearance, causing shadows to their left, and produced the horizontal white retrace lines. U. S. Naval Research Laboratory photographs.

OBSERVING THE SATELLITES

Forty Fragments

In early July's evening skies an unprecedented display of "fireworks" could be seen through telescopes from United States latitudes. Evidently the second-stage rocket used in the triple-payload shot of June 29th (see August issue, page 81) had exploded, giving rise to dozens of fragments. Traveling in very similar orbits, these pieces could be observed by reflected sunlight.

Difficulties in tracking such a swarm of objects optically were first described to the writer by Dennis Smith, who telephoned in the Cincinnati, Ohio, Moonwatch team's observations made with a 14-inch telescope trained on the orbit plane. The Moonwatch group led by Arthur Leonard of Sacramento, California, and skilled observers associated with the Research Station for Satellite Observation also reported problems in tracking simultaneously observed objects.

The Able-Star rocket was described as nearly 15 feet long and about $4\frac{1}{2}$ feet in diameter, weighing nearly 1,300 pounds. More than 40 fragments, some probably quite small, resulted from its breakup. All of them traveled in nearly the same initial orbit plane, but had periods of revolution between 100.4 and 107.2 minutes, so the faster ones began to lap the slower in about a day.

Although their perigees are comfortably high, there will be much confusion in continually identifying all these small satellites.

The vast amount of observational data is processed at a new tracking and computing center that began operation on July 1st. Situated at Ent Air Force Base, Colorado Springs, Colorado, and organized under the North American Air Defense Command, the new installation is called "Spadats," which stands for "Space Detection and Tracking System."

It must maintain surveillance of all satellites that may be possible military threats to the United States or Canada. In order to recognize new objects, the agency must keep tabs on all known ones, taking over the operational assignment formerly handled by Space Track, which has become a research and development unit at Hanscom Field, Massachusetts. Spadats operates under military rules and is permitted to disseminate tracking information only under certain conditions, and then only through the National Aeronautics and Space Administration.

Based upon early Spadats figures, it is likely that the explosion of the rocket occurred slightly before the end of its first revolution, but there are a few fragments whose orbits do not seem to fit this theory. More observational data may solve the problem.

Other mishaps giving rise to unexpected satellite components have occurred. Sputnik IV evidently blew up when something went amiss in its re-entry sequence, and eight pieces suddenly appeared in place of one. For the reconstruction of such an event long after it happened, see the article on $1959\varepsilon2$ in this department for April, 1960, page 346.

Curiously, this latest launching that produced so many satellites had a single deficiency. While Transit IV-A, designated $1961o1$, did attain its separate orbit and is functioning as planned, the other two payloads remain attached to one another, and are being jointly tracked as $1961o2$. The rotation rate of the combination is slower than designed for Solar Radiation III, so this portion is producing data at about half the desired rate. Also, it covers a photometer aboard the Injun section. Nevertheless, the experiment as a whole is more successful than was Transit III-B, where two payloads and the Able-Star rocket all remained attached together throughout their abbreviated lifetime.

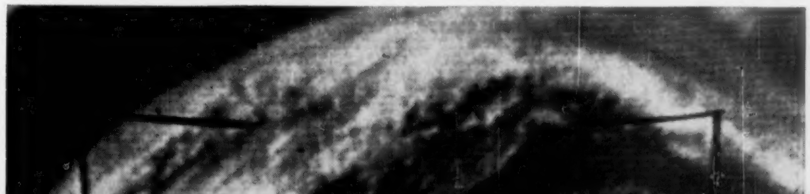
The anomalistic period for $1961o1$ initially amounted to 103.823 minutes, and that for $1961o2$ was only half a second greater. For both, orbital inclination was near 67 degrees, and apogee about 629 miles. Respective perigee heights were 556 and 558 miles.

Another Weather Satellite

Tiros III, third in a series to televise the earth's cloud cover and to make infrared measurements of the earth's temperature, was launched from Cape Canaveral on July 12th at 10:25:10.9 Universal time. Like Tiros II, it used a three-stage Thor-Delta vehicle, which placed the 285-pound payload into an orbit tailored for observation of hurricane-breeding areas during the season when these storms begin.

Although Tiros II was launched last November, with an estimated useful life of three months, it was still transmitting when Tiros III went up. Since there is now a large library of II's narrow-angle photographs, useful only in specialized research programs, Tiros III was equipped with two wide-angle cameras. This duplication was fortunate, for one of them failed within the first dozen days in orbit. But it had transmitted 2,020 excellent pictures of the earth's cloud cover, and the duplicate system is being used successfully.

Tiros II's wide-angle system had always transmitted blurred pictures, presumably because of an accident during launching, but Tiros III's views are sharp, each covering a field 700 miles square when looking straight down from a height of 400 miles. These pictures are almost immediately

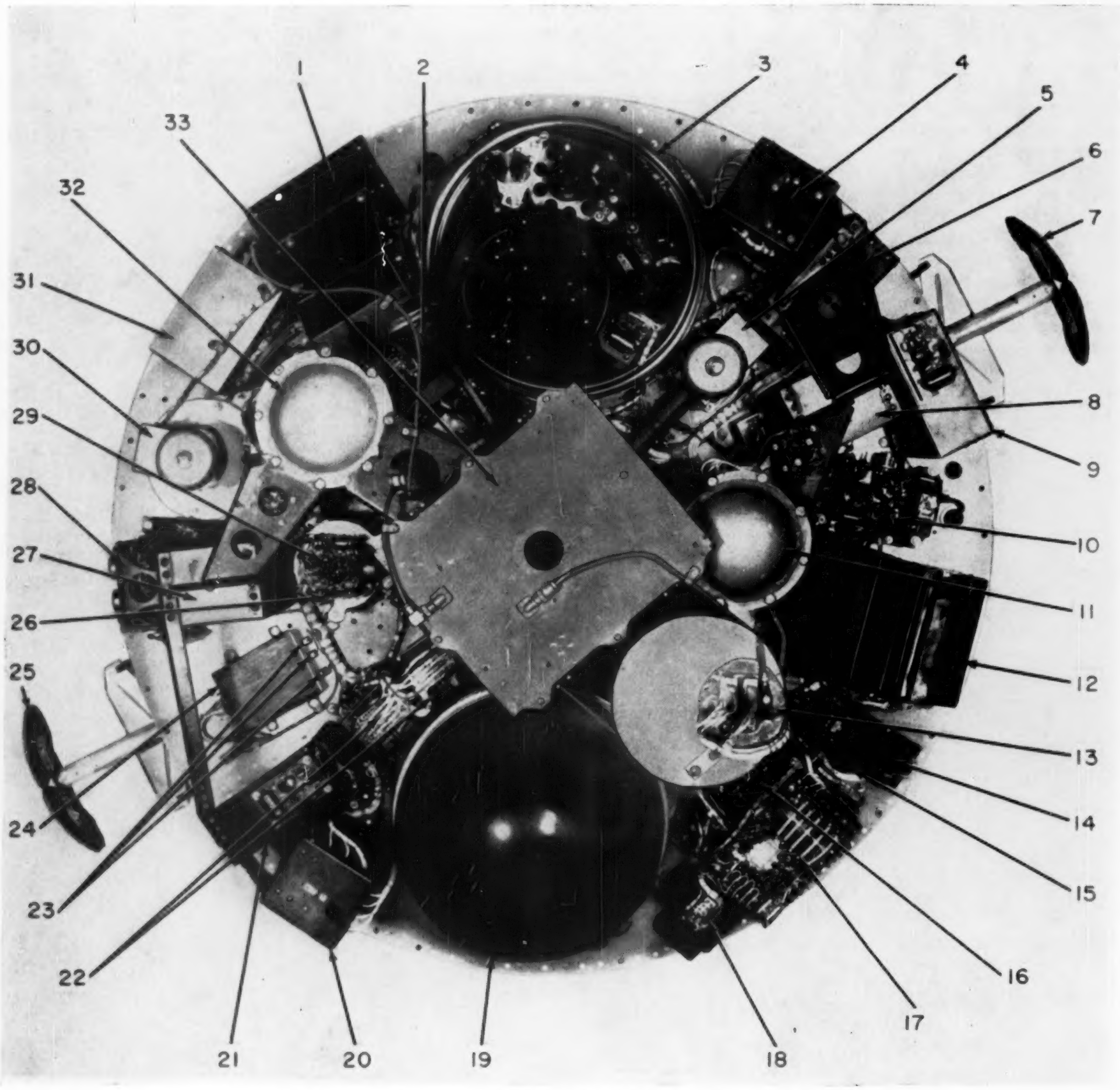


The north-central United States, photographed by Tiros III. At upper right is the Michigan peninsula, while in the foreground clouds cover the central Appalachians. Courtesy National Aeronautics and Space Administration.

available for weather forecasters, and form part of an international program to correlate ground-based observations with satellite studies.

Certain characteristic patterns have already been recognized. Circular cloud systems some 1,000 miles across are associated with the cyclonic winds of low-pressure areas. Large regions blanketed by many small cloud cells, about 40 miles across, are perhaps indicative of powerful convection currents — one of these may sometimes become the eye of a hurricane.

During its first five months, Tiros II transmitted some 2½ million infrared readings daily. Received in analogue form, such data are processed and plotted to show the geographical distribution of



THE PAYLOAD COMPONENTS OF SATELLITE TIROS III

1. TV camera electronics package
2. TV transmitter power converter
3. Tape recorder (cover removed)
4. Tape recorder electronics package
5. TV camera
6. Tape recorder power converter
7. Omnidirectional radiometer
8. TV camera control package
9. Tape recorder power converter
10. Heat-measuring equipment control panel and (below) command receivers
11. Electronic clock
12. Scanning radiometer
13. Heat-measuring experiment electronics (and tape recorder) package
14. Horizon detector
15. Nonscanning radiometer
16. Voltage regulators
17. Battery protection panel and despin timer (below) and TV transmitter
18. TV transmitter power converter
19. Tape recorder
20. Tape recorder electronics package
21. Tape recorder power converter
22. Main telemetry switches
23. Temperature sensors
24. Omnidirectional radiometer electronics package
25. Omnidirectional radiometer
26. Beacon transmitters
27. Auxiliary control package
28. Voltage regulator
29. Attitude control switch
30. TV camera
31. Sync generator and (below) TV transmitter
32. Electronic clock
33. Antenna diplexer and (below) batteries

NASA photograph.

temperature. The procedure is laborious but valuable to weather analysts.

In most respects, Tiros III closely resembles II. There are improvements in the remote-control programmer and in the timing circuits for delayed shots. There is an additional infrared sensor designed to give an almost continuous measure of the gross heat budget of the earth. As before, an elaborate system of sun sensors and computers helps to control the satellite and orient the pictures.

Other features are unchanged: a solar-cell, nickel-cadmium power supply; vidicon detectors and tape recorders for data storage; TV transmitters at 235 megacycles per second; an infrared-data transmitter at 237.8 megacycles; and low-powered tracking transmitters at 108.00 and 108.03 megacycles. These last are also used for "housekeeping" telemetry, including satellite temperature, battery status, and readout from horizon sensors.

The orbit of Tiros III, $1961\rho 1$, has a period of about 100 minutes, as does that of its rocket's final stage, $1961\rho 2$. Apogee heights are 513 and 511 miles, respectively. Both had perigee heights of 460 miles and orbital inclinations close to 48 degrees.

Midas III

AN EXPERIMENTAL PAYLOAD to test the value of satellites as detectors of ballistic missile launchings was sent up by the U. S. Air Force from the Navy's missile facility at Point Arguello, adjacent to Vandenberg Air Force Base in California. Twice earlier the countdown on the Atlas-D booster for Midas III had proceeded to the firing command without the rocket rising from its pad. But in heavy fog on July 12th, at about 15:12 Universal time, the first stage did blast off, initiating one of the most successful launching maneuvers yet conducted by American engineers.

The shoot was aimed slightly west of due south. Soon after the Atlas burned out and separated from the second-stage Agena B, this stage's 15,000-pound-thrust engine ignited briefly to put the vehicle into an eccentric orbit, the apogee being more than 2,000 miles high. Then, after swinging past the South Pole and while approaching its first apogee over the Indian Ocean near Madagascar, the Agena B fired again. The orientation and thrust control were excellent, for the whole orbit became very nearly circular — perigee and apogee respectively lie only a few dozen miles below and above the satellite's mean height of some 2,141 miles.

A perigee as great as 2,084 miles above the earth's surface is almost unprecedented. Only Lunik III had a greater height, but this was acquired from a perturbative encounter with the moon. The 950-mile perigee of Echo I was the highest previously attained through rocket propulsion alone.

At its great height Midas III commands a broad view of the earth. From any one orbital position, about a sixth of the globe can be seen, and in each revolution more than three-fourths of the surface is exposed to view. However, the effective coverage of the satellite's infrared (or other) sensors may be considerably less than this.

Glenn Corrington, payload engineer of the Radio Corporation of America, which is the prime contractor for NASA on this project, looks over some instruments carried by Tiros III. Many of these are seen installed in the satellite in the picture on the facing page. NASA photograph.

Nothing has been disclosed concerning these devices, but we may suppose that several types are being tested simultaneously. In general, ballistic missile launchings are spotted as newly originating major heat sources that rise rapidly through the selective screen of the atmosphere to heights where no other such heat sources are ever found.

Two earlier Midas attempts were made from Florida, aimed at lower circular orbits of small inclination, utilizing the Agena A as the spacecraft. This stage evidently failed to separate from its Atlas booster on February 26, 1960. Orbit was attained on May 24, 1960, although the satellite's radio failed after two days.

It has been unofficially conjectured that Midas III receives much of its power from solar cells, replacing some of the batteries carried in the earlier versions, each of which outweighed Midas III by at least 1,000 pounds. Still, the latter's weight is given as 3,500 pounds, considerably more than the Agena B's in the Discoverer series, and its size is greater, about five by 30 feet. Presumably the extra dimensions are needed for the detection instruments, telemetry, and power supply. Undoubtedly this spacecraft is earth-oriented, and its solar panels may be steerable also.

The Midas system is controlled from the Sunnyvale test center. Tracking and telemetry receiving stations are presently located at Vandenberg Air Force Base; Kaena Point, Hawaii; and New Boston, New Hampshire. A new Midas station will be built in England, eventually to be operated by the Royal Air Force.

Midas III is designated satellite $1961\sigma 1$. Its orbital period is about 161.5 minutes. An object believed to be its nose fairing,

which probably separated before velocity was fully attained for the initial eccentric orbit, is designated 1961σ2. Its perigee amounted to only about 80 miles, apogee to 2,200 and the period to 502 minutes. During its brief lifetime, its orbit was nearly polar, like 1961σ1.

Discoverer XXVI

THE 26th Discoverer satellite was sent aloft from California at about 23:30 Universal time July 7th. More than two days later, during the 32nd revolution of the 2,100-pound Agena-B stage, its 300-pound re-entry capsule returned through the atmosphere successfully.

As the capsule drifted downward over the Pacific Ocean some 60 miles northwest of Kauai, Hawaii, at about 2:35 UT on July 10th, its parachute was snared by an Air Force C-119 recovery plane. This is the fourth time a Discoverer capsule has been caught in mid-air, and the payload was the sixth to be successfully returned for study to the Sunnyvale, California, headquarters of the 6594th Test Wing (Satellite).

Discoverer XXVI carried samples of the same chemical elements as its predecessor (August issue, page 82), except that silicon and lead were substituted for cadmium and gold. Because silicon is used in solar cells and other devices, it is important to know the way in which it is affected by trapped protons and other particles of the space environment.

Remaining in orbit aboard the Agena B were several instruments designed to telemeter their measurements to ground in the conventional manner. The spatial distribution of cosmic radiation was monitored, and the satellite also rebroadcast data on the spectrum of radio noise from space. On a boom that was extended from the rocket after it reached orbit were mounted a micrometeorite detector and an erosion gauge, consisting of a crystal controlling an oscillator that gradually changed frequency as cosmic dust chipped away at the crystal's surface.

An announced aim of recent Discoverer launchings has been to improve control over the orbital injection velocity, hence to effect a more precise period and more satisfactory recovery operations. There is still much dispersion in the orbital parameters actually attained, as indicated by a comparison of the latest shots.

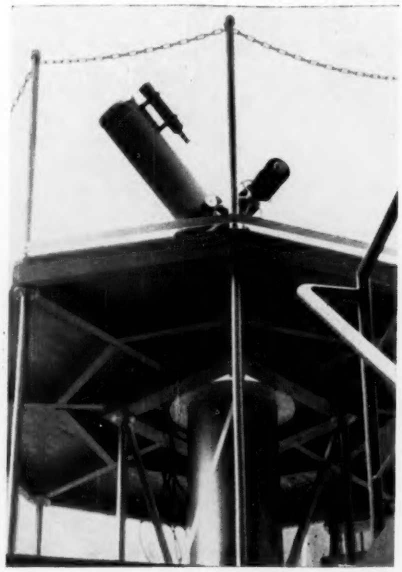
The previous venture, Discoverer XXV (1961ξ), was short-lived, with an anomalistic period of 90.93 minutes; only Discoverer II has orbited Earth in a shorter time. For XXV the perigee and apogee heights were 139 and 259 miles, respectively, and its orbit was inclined 82.11 degrees to the equator. For Discoverer XXVI, designated 1961π, the corresponding figures are 94.97 minutes, 144 and 502 miles, and 82.94 degrees.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

Amateur Astronomers

A High School Observatory and Weather Station

OUR high school at Muskego, Wisconsin, is putting the finishing touches on a combined astronomical observatory and weather station. Planned as an addition to the school, the building is on the southwest corner roof, over a stair well which has the necessary structural strength.



Climbing up to the rooftop observatory, a visitor sees this view of the observing platform and the 6-inch reflector on its pipe pier. Although actual working space in the penthouse is small, school projects have been carried on very satisfactorily.

Since both astronomy and meteorology are to be studied, the seven-foot walls have windows to the south and west and a door opening directly onto the school roof, where several weather instruments are located.

Of two choices of direction for the roof to slide, north or east, the latter was decided upon since the city of Milwaukee lights up that horizon. At times, observations of a particular object must be delayed, but we have found this no real hindrance to our program. One person can easily open and close the roof.

Purchased through the National Defense Education Act, our 6-inch reflector with clock drive is mounted on a steel pipe pier 18 inches in diameter. Surrounding the telescope is a raised hexagonal observing platform, completely separate from the pier. Although both are sunk in a nine-inch concrete floor, slight image vibration in the telescope is noticed when heavy movements are made in the observatory.

The Muskego High School Astronomical Society is beginning to function effectively, with a number of individual or small-group projects, many connected directly with teaching. Although there are no purely astronomical courses in the curriculum, some science classes include astronomical units.

A scale model of the solar system, to show distances of the planets from the sun, is being constructed in one of the longer hallways. Another project is a daily check of sunspots and a rough determination of their diameters. For a constellation-of-the-month display, we are photographing the more prominent constellations with a camera mounted on the telescope tube. To show the apparent movements of the planets among the stars, field photographs are being taken at regular intervals.

We wish to exchange project ideas with other high school astronomical groups.

JEROME STEUBER
and RUSS TOOLEY
Muskego High School
Muskego, Wis.

Muskego High School's combined weather station and observatory. This view from the north shows the roof opened, and in the foreground are weather instruments, including a wind vane, anemometer, and rain gauge.

+++ AMATEUR BRIEFS +++

The Memphis Astronomical Society presented the Tennessee city's museum with a 50-mm. refractor to be used in the youth education program. The telescope formerly belonged to the society's secretary, George P. Turner.

Over 100,000 visitors to the Morrison Planetarium between May 16th and July 2nd saw the astronomical display of the San Francisco Amateur Astronomers, reports president Edward Taylor. On exhibit were 2- to 12-inch telescopes, a spectroscope, photographs, drawings, articles, and mirrors in various stages of grinding. Guests from Brazil, Argentina, Mexico, Sweden, France, England, Burma, and all parts of the United States signed the register.

Two ladies vacationing last spring from Argonne National Laboratory, Illinois, decided to include the new Cornell University radar telescope in their tour to Puerto Rico. Thinking the 1,000-foot array would be fairly near completion, scheduled for February, 1962, they began inquiring of the installation's whereabouts at the nearest town on the map. Blank stares met their questions, until the attendant at the third gas station pointed in the right general direction. A beautiful black-topped highway ran for 10 miles, then abruptly terminated in a roadbed filled with sand and boulders. Undaunted, they pressed on, arriving at the site only to find that the sole signs of human effort on the terrain were some concrete support foundations. The foreman of the small work crew, suspending his activities, delightedly explained the construction to his Yankee visitors.

A 70-year resident in the vicinity of the Allegheny Observatory, when asked by a visitor what the dome on the hill was, announced it to be part of the county jail!

William McManus, president of the Riverton Junior Astronomical Club, has been named an outstanding junior amateur in New Jersey. He has constructed a camera for stellar spectroscopy, in addition to several telescopes.

The moon and Mars proved to be the most popular objects at the Astronomical Society of Harrisburg's star party for about 45 patients at the Pennsylvania state hospital.

Dr. C. W. Gartlein, head of the IGY Auroral Data Center in Ithaca, New York, has been doing some television research on the effect of solar flares on communication. After certain strong disturbances, he has picked up signals from stations as far away as 1,200 miles.

When the ATM's of Boston announce outdoor activities, they show their wariness of New England weather by putting down two dates, the second to be used in case of rain on the first.

An astronomical mnemonic contributed by J. W. Crossland of Fort William, Ontario, recalls the names of the Big Dipper stars from the handle to the bowl, Alkaid, Mizar, Alioth, Megrez, Phecda, Merak, and Dubhe. The series AM AM PM and D may be remembered as "Twice in the morning, once in the afternoon, makes a day."

Ralph Dakin, organizer of the Astronomical League's Northeast region's convention last spring in Rochester, New York, reported that the meeting came out in the black – netting a profit of $5.72.

Helen Sawyer Hogg invites tourists in Toronto to visit the David Dunlap Observatory at Richmond Hill. The buildings are open Saturdays "from April Fool's to Halloween."

G. B. C.

AAVSO FALL MEETING

On October 12-15, 1961, the American Association of Variable Star Observers will celebrate its 50th anniversary by gathering at Harvard Observatory for the annual fall meeting. A special highlight will be a review of the past half century in astronomy by Dr. Harlow Shapley. Further information on the meeting can be obtained from Mrs. Margaret Mayall, Director, AAVSO, 4 Brattle St., Cambridge 38, Mass.

YORK, PENNSYLVANIA

The York Astronomical Society participated in the city's Arts Festival, held June 4-9 on the York Junior College campus. Our display included a satellite viewer, a number of books, and a scale model of Palomar Observatory, made by a 14-year-old junior in the club. A member was on duty to tell interested persons about the activities of our group.

At our regular monthly meetings there is a 5-minute talk on the constellation of the month in addition to the principal 30-minute lecture. Our regular star parties are held in July and August. The society has 27 members, nine of whom are juniors.

MRS. RUTH P. KATHERMAN
871 Grandview Rd.
York, Pa.

PLANETARIUM IN BRAZIL

The first planetarium in Rio de Janeiro, a Spitz model A-2, was dedicated last spring at the Brazilian Naval Academy. It will be used for instruction in celestial navigation.

The 20-foot-diameter dome, ample for the needs of the academy, is in an air-conditioned building which will also house a naval museum.

For civilian schools and other organizations, special shows are held on Saturdays and Sundays. These are supervised by the Brazilian Astronomical Association, whose members act as demonstrators.

ALEXANDRE FUCS
Brazilian Astronomical Association
P. O. Box 2552
Rio de Janeiro, Brazil

THIS MONTH'S PROGRAMS

New Orleans, La.: Pontchartrain Astronomy Society, 8 p.m., Louisiana State University science building. September 15, Dr. George E. Burch, Tulane University, "Some Physiological Aspects of Man in Space."

Shreveport, La.: Shreveport Junior Astronomical Society, 7:30 p.m., Centenary College science hall. September 16, F. C. Boston, "Adventurous Amateurs."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. September 9, Dr. Ernst J. Öpik, University of Maryland, "Surface Conditions on Venus."

MANSFIELD, OHIO

Organization of the Richland Astronomical Society has been recently completed by its eight trustees, and we now look forward to carrying our interest in astronomy to local schools and the general public.

Our observing equipment includes a 5-inch f/13 refractor, several smaller refractors, and 12- and 10-inch reflectors. At our principal viewing site, on an isolated 1,210-foot hill, we poured an eight-foot square concrete slab four feet thick; this provides a solid foundation on which to set the instruments.

Suggestions from other societies for programs and for encouraging membership would be most appreciated.

GILES E. HAMILTON
99 Brickman Ave.
Mansfield, Ohio

A FACE IN NEBULOSITY

The "starry-eyed parrot" in the picture of the Sagittarius starcloud (page 15, July) is certainly interesting, but has anyone noticed the head of a man nearly an inch high in the center of the picture of Rho Ophiuchi on page 35 of the same issue?

Bright nebulosity at the tip of his nose softly lights his face as he gazes intently into space over the reader's left shoulder. His mouth and chin are a little dim, as are his prominent forehead and receding bushy hair. But his eyes and the bridge of his nose are outstanding!

BURRIS SMITH
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OPTICS

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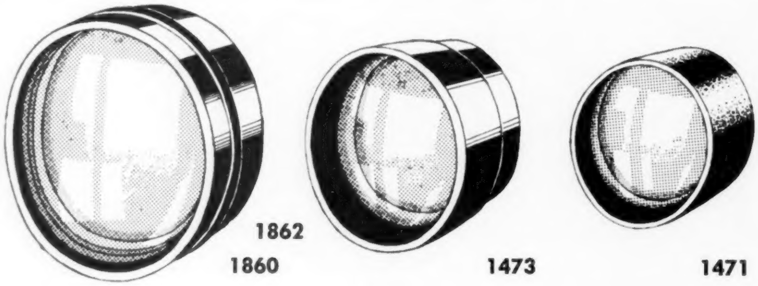

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6" APERTURE f/10 — 60" F. L.	Cat. No. S1861	Unmounted and Coated	$150.00 ppd.
	Cat. No. S1860	Mounted and Coated	175.00 ppd.
6" APERTURE f/15 — 90" F. L.	Cat. No. S1863	Unmounted and Coated	$150.00 ppd.
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S1476	2⅛"	10"	$12.50	S1520	2⅛"	50"	$12.50	S-957	3¼"	40"	$30.00
S1112	2⅛"	11¾"	12.50	S-851	3-1/16"	15"	21.00	S1155	4"	34½"	60.00
S1110	2⅛"	13"	12.50	S1158	3⅛"	19½"	28.00	S1460	4¼"	36"	60.00
S-958	2⅛"	15½"	9.75	S-822	3-3/16"	24½"	22.50	S1159*	4⅜"	42"	60.00
S1145	2⅛"	20"	12.50	S1092	3¼"	26"	28.00	S1225	4⅜"	42"	67.50
S-952	2⅛"	23½"	12.50	S1093	3¼"	28"	28.00	S1474*	5-1/16"	24¾"	75.00
S1431	2⅛"	30"	12.50	S1139	3¼"	30"	28.00	S1475	5-1/16"	24¾"	85.00
S1432	2⅛"	40"	12.50	S-955	3¼"	34½"	28.00	*Not coated.			

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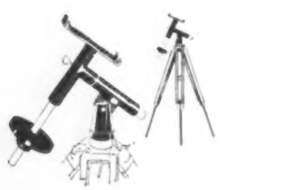
EACH KIT CONTAINS: Mirror blank, plate-glass tool, eyepiece lenses, first-surface diagonal mirror, assorted abrasives, tempered pitch, inspection magnifying lens.

Cat. No.	Mirror Diam.	Thickness	ppd.
S2053	4¼" (f/8 curve)	¾"	$ 7.50
S2093	4¼" (flat)	¾"	7.50
S2054	6" (f/8 curve)	1"	11.95
S2094	6" (flat)	1"	11.95
S2055	8" (flat)	1⅜"	19.50
S2056	10" (flat)	1¾"	30.75*
S2057	12" (flat)	2⅛"	54.75*

*f.o.b. Lynbrook, N. Y.

Equatorial Mount & Tripod



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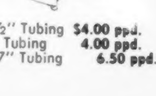
S1429	3-3/16"	42"	$ 8.70
S1506	4¼"	45"	13.50
S1507	6"	60"	25.00
S2188	6" parabolic	48"	49.50

Mirror Mounts



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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Celestial Photography with an 8-inch Reflector

THE astronomical pictures on the following two pages are representative of my collection of some 35 negatives, taken with a homemade 35-mm. camera attached to the 8-inch f/5.4 reflector described on page 358 of the June issue.

Although I was tempted to use a commercial camera body, the necessity of having the film plane at the front of the camera made that impossible. My aluminum and steel box accepts standard 35-mm. cartridges, which I normally load with enough film for six exposures.

Rough focusing is with a ground-glass field viewer which fits onto the shutter mechanism in place of the film box. Critical focusing is done with a knife-edge in the film plane and a small telescope. The knife-edge arrangement is relatively new and cannot be tested completely until the poor commercial figure on the mirror, grossly overcorrected, can be remedied.

The 2¼-inch f/20 guiding refractor is equipped with a built-in 3x Barlow lens. At a magnification of 200, a star's Airy disk is plainly visible under good seeing conditions. The power supply and frequency control mentioned in June make guiding simple, but accuracy is limited by flexure in the telescope tube and secondary support. Therefore, I plan someday to guide at the focus of the primary mirror, using a photographic head carrying a secondary with a three-inch minor axis.

Since my reflector has no permanent housing, although its pier is fixed in the ground, it must be carried out and aligned on the pole every time it is used. This adjustment is facilitated by a Polaris telescope with diurnal-circle reticle, built into the mounting. The simple procedure for setting up the instrument takes less than a minute.

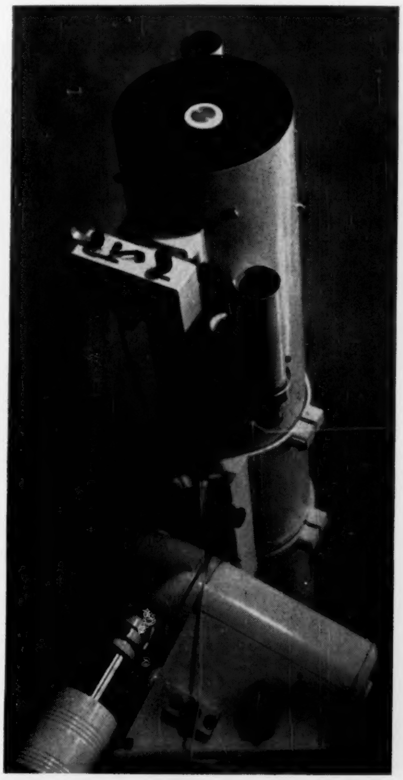
Guide stars are chosen using a special overlay for the Skalnate Pleso star charts that gives the finder's field for any object and thus facilitates speedy location, whether or not the object is visible in the finder. No setting circles are used; the finder's illuminated reticle is ruled off in one-degree squares, and these plus the atlas make circles superfluous. The relatively small aperture of my guide telescope makes necessary using guide stars no fainter than 6th magnitude.

A second special overlay allows me to read directly from the atlas the angular distance between the object to be photographed and the nearest suitable star. As yet there has been no difficulty in finding one within the three-degree limit by which the mounting permits the guide telescope's axis to be offset in any direction. Positioning an object on the film and locating and centering a guide star seldom require more than five minutes.

All of my recent exposures have been made on Eastman 103a-F panchromatic spectroscopic film, though more readily available films have been used with some success. Panatomic-X avoids grain in enlargements, but exposures are almost prohibitively long with it, so Plus-X is used if some grain is tolerable. Neither of these films nor Tri-X has been successful on objects of low surface brightness; apparently the films' sensitivity falls off very rapidly at low light levels. Ansco's Super Hypan has proved an acceptable substitute for 103a-F, being perhaps two-thirds as fast as the Kodak film. I have not tried Eastman 103a-O or 103a-E, the two most widely used emulsions for astronomical work.

Having experimented with many developers, I now use Ethol UFG exclusively. Super Hypan is developed for 20 minutes at 65° Fahrenheit, and 103a-F for 10 to 15 minutes at 70°. Grain could be reduced somewhat by longer exposures and shorter development times.

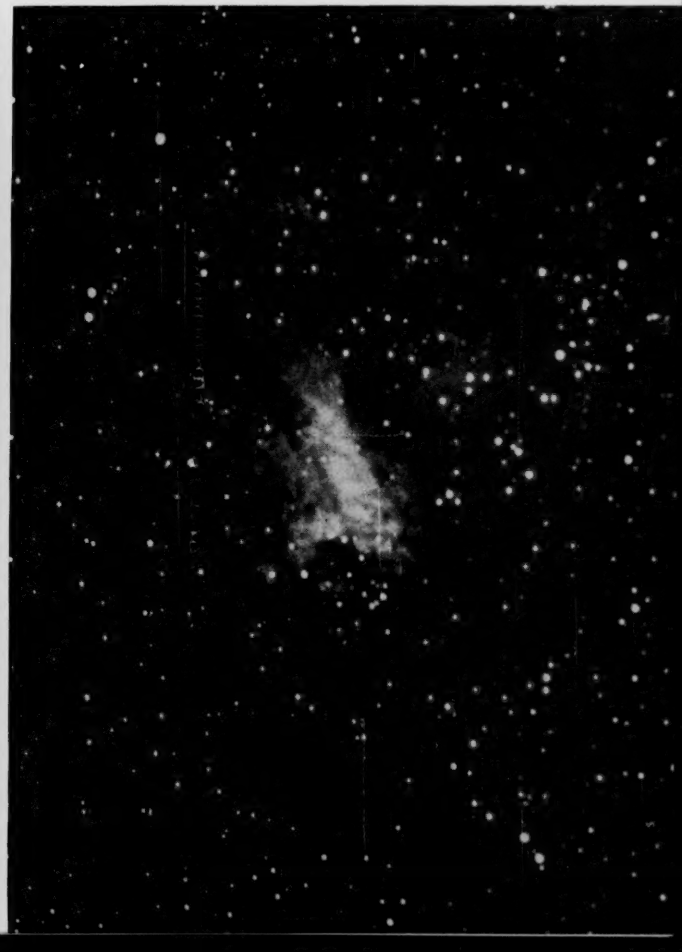
The Rosette nebula (top left on page 150) in Monoceros is a one-hour exposure



James E. Gunn's 8-inch reflector set up for photography at the Newtonian focus, where the homemade camera box and controls are attached. For a general view of this instrument and its accessories, see the June issue.


These photographs were taken by James E. Gunn with an 8-inch Newtonian telescope of his own design. The two above are the Rosette nebula and the Pleiades. Below are M16 and the Great Nebula in Orion.


The Whirlpool and Veil nebulae are pictured above; below are the Horsehead and Omega nebulae. Except for the Omega (which has west upward), all photographs have south toward the top. See descriptive text on pages 149 and 152.



made last December on 103a-F. I would have liked to extend the exposure to two hours, but heavy dew was forming and freezing on my equipment, and I was afraid that the secondary would dew and spoil the plate. As it happened, the declination drive froze, and correction in that co-ordinate had to be made by hand, until finally the grease in the declination bearing also froze, rendering it immobile. The cluster in the center is number 2244 in the *New General Catalogue,* and is surrounded by nebulosity which is about a degree in diameter.

The second photograph at the top of the page is a 30-minute exposure of the Pleiades, showing the well-known reflection nebulosity surrounding them. The three bright stars in a nearly straight line across the middle of the picture are (left to right) Electra, Alcyone, and Atlas. Above them is Merope (left); Maia is below and to the left. At the right, Pleione is just below Atlas. One inch equals about 16 minutes of arc in this enlargement.

The famous Whirlpool nebula, M51, in the third photograph is enlarged about 20 times from the plate scale. A 40-minute exposure on 103a-F emulsion clearly shows the faint arm connecting NGC 5194, the Whirlpool itself, and NGC 5195, its companion.

One hour on the same emulsion was sufficient to obtain a view of one part of the Veil nebula (NGC 6992). Compare this five-times enlargement with the photograph of the same nebulosity in Cygnus by the Lick 120-inch reflector (December, 1960, page 339).

M16, a very loose and irregular 6th-magnitude cluster in Serpens, was exposed for 30 minutes on 103a-F. At lower left on page 150, the photograph has been enlarged about eight times. Notice the intricate detail and intruding dark lanes in the surrounding nebulosity.

Next is a 40-minute exposure of M42, the Great Nebula in Orion. Although the central region is somewhat overexposed, the delicate tracery of the outer fringes is well shown in this enlargement of about five times. One inch here equals some 14 minutes of arc.

During a 1½-hour exposure of the Horsehead nebula, a knock on the eyepiece of the guide telescope caused a slight movement of the instrument resulting in the short streaks extending to the right of many of the brighter stars. Taken on Super Hypan film, this view covers part of IC 434, the nebulosity running from Zeta Orionis (bright star at the bottom) southward. The Horsehead is actually dark material in front of IC 434. This section of Orion was discussed in detail in SKY AND TELESCOPE for December, 1957, page 84. One inch is approximately 13 minutes of arc.

M17, the Omega nebula, was photographed for 40 minutes on 103a-F. In this enlargement of about seven times from the plate scale, west is at the top. The nebula is about 46 minutes of arc high and 37 wide.

With a just-completed astrograph that will take 4-by-5 plates, I am planning to record the Milky Way in the region of Orion and Monoceros. I do not hesitate to recommend astrophotography to any amateur who has the patience to perfect his centering, focusing, and guiding techniques.

JAMES E. GUNN
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MESSIER OBJECTS FOR FALL VIEWING

GIVEN below is the third seasonal listing of Messier objects, as compiled by the Messier Club at the Royal Astronomical Society of Canada's Ottawa Centre. Spring objects were listed in the April, 1961, issue, page 219; summer objects in June, page 344.

No one particular type of deep-sky object dominates the autumn sky. The last few of summer's abundance of globular clusters can be found in Pegasus, Aquarius, and Capricornus. A number of open clusters are scattered through Cassiopeia and Perseus, while M73 in Aquarius is an asterism of only four stars.

The famous Andromeda nebula and its companion provide good examples of a spiral and an ellipsoidal galaxy. M77 is another spiral seen from a slightly different angle. Both M33 and M74 are many-armed spirals, in which the dark lanes are quite evident on photographs.

M	*Type*	*R. A.* h m	*Dec.* ° ′	*Mag.*	*Size* ′
PEGASUS					
15	G	21 28	+11 57	6	12
AQUARIUS					
2	G	21 31	−01 03	7	12
72	G	20 51	−12 44	9	5
73	C	20 56	−12 50		
CAPRICORNUS					
30	G	21 38	−23 25	8	9
CASSIOPEIA					
52	C	23 22	+61 19	7	13
103	C	01 30	+60 26	7	6
PERSEUS					
76	P	01 39	+51 19	11	2 × 1
34	C	02 39	+42 34	6	30
ANDROMEDA					
31	S	00 40	+41 00	4	160 × 40
32	E	00 40	+40 36	9	3 × 2
TRIANGULUM					
33	S	01 31	+30 24	7	60 × 40
PISCES					
74	S	01 34	+15 32	11	8 × 8
CETUS					
77	S	02 40	−00 14	9	2 × 2

Symbols for type of object are: C, open cluster; E, ellipsoidal galaxy; G, globular cluster; P, planetary nebula; S, spiral galaxy. 1950 co-ordinates and approximate visual magnitudes are given.

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DEEP-SKY WONDERS

MOST beginners start with a small portable telescope that is taken out for observing on clear nights. Since it is set up anew for each session, the polar axis is seldom well aligned on the north celestial pole. To make matters more difficult, these instruments usually do not have setting circles nor clock drives and may not even have finders. How, then, does one find faint clusters and nebulae?

Slow but satisfactory is the sky-drift procedure, and it works just as well for an altazimuth mount as an equatorial one. All that is needed are a watch and a low-power ocular with a field of view of about a degree. The method consists of setting the telescope on a bright star west of the desired object but at the same declination. Then the instrument is left stationary while the stars drift through the field. After a length of time equal to the difference in right ascensions of star and object, the latter will be in the field of view.

No drive is needed, and since an eyepiece with a one-degree field covers about four minutes of time for equatorial stars, even the timing is not critical. Once the object has been found, however, it must then be followed by some means.

To illustrate this procedure, we give two examples of objects that are well placed for September viewing. Both are fairly bright, being visible in a 3-inch. The first is Messier 72, a 9th-magnitude globular cluster in Aquarius, at right ascension $20^h\ 50^m.7$, declination −12° 44′ (1950 co-ordinates). It has a diameter of 5′, and even in a small telescope cannot be confused with a single star, though it takes a 10-inch to make it stand out. To find M72, the telescope is set on Alpha Capricorni; 36 minutes later the globular will be in the center of the field.

Finding the next object, at $21^h\ 01^m.4$, −11° 34′ (1950), involves knowing the angular diameter of your ocular's field, and this can be estimated by looking at the moon, which is about half a degree across. Set the telescope a degree north of M72 (using your estimated field diameter) and wait 10½ minutes. NGC 7009, a famous planetary — the Saturn — will drift into view. The nickname comes from the planetary's appearance in large telescopes, where two thin rays can be seen jutting from the disk.

This planetary is bright, of magnitude 9 with a 12th-magnitude central star, and is sharp to the edges. It requires at least a 6-inch telescope to show the central star.

In using the drift method for locating objects, it is easy to select starting stars from the Skalnate Pleso atlas.

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AURORA PREDICTIONS CONFIRMED

NEWSLETTERS 46 and 47 from C. W. Gartlein at the IGY Auroral Data Center, Cornell University, predicted northern lights for June 28-29, July 4-5, and July 17-18, based on a 27-day solar rotation cycle. On each of these nights the predictions were upheld, medium to bright auroras being seen from Madison, Wisconsin.

On the June date a glow spread about 40° to either side of the north point of my horizon. The reading on the electronic measuring device in my observatory varied between 5 and 15, indicating disturbances in the local magnetic field. Major storms during the International Geophysical Year caused pulsations between 50 and 100, according to other observers in this area.

On July 4-5, the skies cleared around Madison long enough for me to glimpse one of the most interesting auroras of the summer. Although the horizon was still blocked by clouds, a glow and rayed arcs seemed to be moving slowly from west to east across the north. After an hour of observing, at 11:00 p.m. Central daylight time, I observed a light red area developing in the northeast. My electronic equipment suggested that the aurora continued well into the night, and that it may also have increased in size. However, the equipment is affected by thunderstorms, and on that date there was a squall line about 60 miles south of my station.

Matching this aurora was the one on

July 17-18, which I first observed as a medium-bright glow at the end of astronomical twilight. Quiet and rayed arcs appeared late in the display.

An extensive aurora that was not expected by the IGY center occurred on July 14-15. At 10:15 p.m. CDT, when I began observing, a medium to bright quiet arc glowed in the north, seven to 15 degrees above the horizon most of the time. Just after midnight a series of faint "flames" formed; they continued to flicker to a maximum altitude of 23° until blotted out by clouds at 1:00 a.m.

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TRANSITS OF JUPITER'S RED SPOT

Recently the famous red spot on Jupiter has become quite prominent. The hollow has been visible for some time, and reddish color has now returned to the oval. Clyde W. Tombaugh of New Mexico State University has sent in the following ephemeris computed by C. M. Anderson. For each day in September, Universal times are given for transits of the spot across Jupiter's central meridian.

September 1, 7:25, 17:21; **2,** 3:17, 13:12, 23:08; **3,** 9:04, 18:59; **4,** 4:55, 14:51; **5,** 0:47, 10:42, 20:38; **6,** 6:35, 16:29; **7,** 2:25, 12:22, 22:16; **8,** 8:12, 18:09; **9,** 4:03, 13:59, 23:56; **10,** 9:52, 19:47.

11, 5:43, 15:39; **12,** 1:34, 11:30, 21:26; **13,** 7:21, 17:17; **14,** 3:13, 13:08, 23:04; **15,** 9:00, 18:55; **16,** 4:51, 14:47; **17,** 0:44, 10:39, 20:35; **18,** 6:31, 16:26; **19,** 2:22, 12:18, 22:13; **20,** 8:09, 18:05.

21, 4:00, 13:56, 23:52; **22,** 9:48, 19:43; **23,** 5:40, 15:37; **24,** 1:31, 11:27, 21:24; **25,** 7:18, 17:14; **26,** 3:11, 13:05, 23:01; **27,** 8:58, 18:52; **28,** 4:50, 14:46; **29,** 0:42, 10:37, 20:33; **30,** 6:29, 16:24.

SUNSPOT NUMBERS

The following American sunspot numbers for June have been prepared by the Radio Warning Services Section, Boulder Laboratories of the National Bureau of Standards, from AAVSO Solar Division observations.

June 1, 31; **2,** 25; **3,** 38; **4,** 37; **5,** 43; **6,** 43; **7,** 41; **8,** 40; **9,** 54; **10,** 57; **11,** 58; **12,** 58; **13,** 61; **14,** 72; **15,** 84; **16,** 102; **17,** 107; **18,** 100; **19,** 115; **20,** 126; **21,** 115; **22,** 102; **23,** 80; **24,** 65; **25,** 59; **26,** 43; **27,** 46; **28,** 48; **29,** 53; **30,** 53. Mean for June, 65.2.

Below are provisional mean relative sunspot numbers for July by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

July 1, 60; **2,** 65; **3,** 68; **4,** 63; **5,** 44; **6,** 50; **7,** 51; **8,** 60; **9,** 65; **10,** 73; **11,** 85; **12,** 96; **13,** 86; **14,** 107; **15,** 100; **16,** 94; **17,** 92; **18,** 82; **19,** 86; **20,** 85; **21,** 85; **22,** 75; **23,** 81; **24,** 78; **25,** 63; **26,** 62; **27,** 53; **28,** 42; **29,** 32; **30,** 30; **31,** 34. Mean for July, 69.3.

BOOKS AND THE SKY

TELESCOPES

Gerard P. Kuiper and **Barbara M. Middlehurst**, editors. University of Chicago Press, Chicago, 1960. 255 pages. $8.50.

THE TELESCOPE is one of the most important instruments ever invented, and it is therefore appropriate that, from time to time, it should be discussed in considerable detail and from varying points of view. Although the level of treatment varies considerably from chapter to chapter, this book furnishes excellent reading and reference information for professional and amateur alike. This reviewer's one regret is that *Telescopes* was not available in the winter of 1960 as an aid for teaching a graduate course in radio astronomy.

There are 12 chapters, plus a useful appendix listing optical telescopes of 20-inch aperture or larger (exclusive of solar instruments), which is so up-to-date that it includes the recently completed 102-inch Russian reflector in the Crimea. The 200-inch Hale and 120-inch Lick reflectors have chapters of their own, the former containing 11 full-page reproductions of the famous drawings by Russell W. Porter. The high standard of illustration they set is maintained by many more photographs, of subjects both old and new, throughout the book.

Other chapters treat specialized instruments: the transit circle, the photographic zenith tube and dual-rate moon-position camera, and the Danjon impersonal astrolabe. Large-reflector design, Schmidt cameras, telescope drives, radio telescopes, and radio astronomy radiometers are also discussed, and there are two chapters on astronomical seeing. Solar instruments are not included in this book, nor will they be discussed in a succeeding volume that is to cover both long- and short-focus astrographs, as well as spectrographs and photometers.

I found J. G. Bolton's discussion of radio telescopes especially interesting. He describes interferometers first, then large arrays such as the Mills cross, and finally steerable reflectors. A few well-chosen diagrams and tracings aid the text, and there are 18 large pictures of radio telescopes. Nevertheless, this explosive field is developing so fast that no mention could be made of the 600-foot Sugar Grove dish, the 300-foot Green Bank reflector, the University of Illinois' 600-by-400-foot "hole in the ground," the mile-long Mills super-cross, and a host of other large instruments under construction or being planned.

On the conservative side, the transit circle chapter by C. B. Watts is useful reading, especially for those astrophysicists who depend on proper motions to support their discussions of distance scales, stellar luminosities, space motions, and cluster membership, but who are inclined to regard a proper motion as something to obtain from a catalogue rather than through observation. Dr. Watts does not discuss one vital point: Why do photographic zenith tube observations have probable errors only one third those obtained with a transit circle, for zenith stars observed differentially in both cases? A constructive answer to that question would seem an even more important break-through than the Markowitz dual-rate moon camera.

One of the really urgent needs in modern stellar astronomy is a revised and extended Boss *General Catalogue*. That work does not and could not include data from some 100 positional catalogues derived from modern transit circle observations. These million-odd positions are "frozen assets" in their present form, but we now have electronic computing tools to handle what would otherwise be an impossibly long and tedious task. Systematic and accidental errors in stellar proper motions might well be reduced by a factor of three or more, and useful proper motions derived for five times as many stars as are in Boss.

André Danjon's chapter on the impersonal astrolabe is completely convincing as to the value of this highly specialized device in the correction of systematic errors in fundamental systems. More such instruments are needed in both hemispheres and on or near the equator.

The chapter on seeing and observatory site selection by A. B. Meinel is most useful, as is another on seeing by J. Stock and G. Keller. Astronomical observatories in the past have often been very poorly located. Even the two largest telescopes in the Southern Hemisphere are not at optimum sites. This is in direct violation of Irwin's law, which states that the observational productivity of a station varies as the fifth power of the observing conditions. I have the feeling that in the past some sites have been chosen for their nearness to universities or shopping centers rather than for their suitability for observing.

Although a great deal has been learned about seeing conditions, it is still necessary to do extensive and expensive site testing. Dr. Stock's interferometer would seem to provide the basic means of evaluating seeing for a large reflector from observations with a relatively portable field instrument. For instance, are there sites of excellent seeing in the desert? This point is particularly important in the present Air Force-AURA site survey in Chile, using the Stock interferometer, where desert locations are possible that promise more than 320 completely clear nights a year.

One fundamental fact seems to have emerged in recent years. Seeing is bad in an inversion layer, that is, when the ground is cooled by radiation during the

night so at higher levels warm air may overlie cold air, producing turbulence. For example, a characteristic of the South African veld is frequent and sudden deterioration of seeing late in the evening. The answer here may be to select a mountain whose summit remains above the inversion layer all night long.

With the advent of the space age, the telescope has assumed a marked new significance. There is, however, an increasingly critical shortage of trained astronomers — we need many new theoretical astrophysicists and celestial mechanicians. Much more important will be the demand for well-trained young observational astronomers thoroughly familiar with the designs and uses of telescopes, spectrographs, and photometers. Yet, most universities in this country do not have *at excellent sites* the moderate-sized telescopes that are absolutely necessary for the training of such astronomers. Our space programs will seriously suffer unless many such facilities are provided in the near future.

This book is the first of a nine-volume compendium of astronomy and astrophysics, entitled Stars and Stellar Systems, under the general editorship of Dr. Kuiper and Miss Middlehurst. The entire series has been carefully planned and is being written and edited at the highest professional level. *Telescopes,* first of the series, is a quality book in every way and is of moderate cost.

JOHN B. IRWIN
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Indiana University

THE UNIVERSE AT LARGE

Hermann Bondi. Doubleday and Co., Inc., New York, 1960. 154 pages. 95 cents, paper bound.

AN INCREASE of 50 per cent in the length of Hermann Bondi's book would have more than doubled its worth as a nontechnical introduction to modern cosmology. Many valuable concepts could be barely touched upon — the reader is left dangling.

The evolution of elements (a most dramatic operation), tests of general relativity, the color-magnitude array, methods of measuring distances of stars and galaxies — these subjects are too lightly treated if the reader is to have more than an appetizer. But the chapters on theories and tests of cosmology provide an excellent elementary introduction to the hypotheses that are commonly named evolutionary (big bang) and steady state (continuous creation). Cosmic magnetic phenomena are also lucidly though briefly discussed.

For an inexpensive paperback, the halftone illustrations are good, but most of the drawings help the text very little, and a few of them distinctly confuse the reader. It is unfortunate for the writers of popular books on astronomy that our sky has so few striking objects suitable for decoration and instruction. We must use the same galaxies, nebulae, clusters, and star fields over and over. Beings in other celestial locations may be better off. Our illustrative poverty is perhaps sufficient excuse for resorting to imaginative sketches of evolutionary processes and the occasional faking of colors.

Dr. Bondi's presentation is commendable for its frequent reference to the tentative nature of our astronomical theories. Observations are still too scanty for confidence that our interpretations are durable.

HARLOW SHAPLEY
Harvard Observatory

ASTRONOMIE

Joachim Herrmann. C. Bertelsmann Verlag, Gütersloh, West Germany, 1960. 393 pages. DM 11.80.

NEW RESULTS of astronomical progress are published almost every week. This rapid advance of the science renders it rather difficult for an author to combine all the facts, prospects, and new theories in one comprehensive, up-to-date book.

The new *Astronomie, eine moderne Sternkunde,* fills a gap in modern German-language astronomical literature accessible to amateurs. The book contains reliable and accurate information throughout, and is especially attractive as an easily read handbook and general text. About 200 good illustrations and tables supplement the author's explanations.

Astronomie first deals with the history of astronomy, and then looks at the scien-

SKY-GAZERS EXCHANGE

tific work being done at observatories around the world. The development of instruments that astronomers use is traced from the first telescope made by Hans Lippershey in 1608 through those of Kepler and Fraunhofer to modern giant reflectors and radio telescopes.

Included is an introduction to atomic structure. Next comes an explanation of the daily motions of the heavens, and then, systematically and thoroughly, the sun, moon, and the rest of the members of the solar system are introduced. The concluding third of the book deals with stellar astronomy — star charts and catalogues, double stars, variables, novae, clusters, interstellar matter, the Milky Way, and other galaxies.

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THE TECHNIQUE OF OPTICAL INSTRUMENT DESIGN

R. J. Bracey. Macmillan Co., New York, 1960. 316 pages. $9.00.

AN ENGINEER or other technical worker who is at ease with algebra and trigonometry and is able to apply integral calculus without pain can make good use of R. J. Bracey's book in computing the simpler optical systems.

The Technique of Optical Instrument Design deals with the mathematical computation of image errors and methods of reducing them. It is not a book that describes instruments themselves; it does not give examples of, or prescriptions for, elements or systems. The treatment is derived exclusively from geometric optics, although wave optics is mentioned. Schmidts, Maksutovs, and refractors are covered in three pages, reflectors in one. Ramsden and Kellner eyepieces are accorded 17 pages.

The author, in common with many British designers, carries third-order algebraic methods farther in the computation scheme than do contemporary American workers, despite the approximate nature of such methods. His treatment of skew rays is good, and the presentation is succinct and clear.

The errors of algebraically computed systems are determined trigonometrically, and dimensional changes are made until the aberrations are brought within the assigned limits. The methods and notations of A. E. Conrady and H. Dennis Taylor are used in the treatment of surfaces and of elements.

Thorough mastery of this book should enable an optical worker to compute with facility, but this would be only the first step to proficiency in optical design, which requires knowledge in fields not considered here. For this reason, a better title for this work might be "Techniques of Geometric Optical Computation."

HORACE H. SELBY
San Diego, Calif.

NEW BOOKS RECEIVED

Astronomischer Jahresbericht, Vol. 59, 1961, *Astronomisches Rechen-Institut,* Mönchhofstrasse 12-14, Heidelberg, West Germany. 517 pages. DM 72, paper bound.

The astronomical literature published world-wide in 1959 is listed by subject in this latest volume of a standard comprehensive reference work, the more important articles being briefly summarized in German. The categories by which the titles are listed have been changed from the previous volume, and the subject index is in German, rather than English.

History of the Rittenhouse Astronomical Society, 1888-1960, *Cecil M. Billings,* 1961, *Rittenhouse Astronomical Society,* Franklin Institute, Philadelphia 3, Pa. 123 pages. $5.00.

Many pictures and facsimiles of documents illustrate this detailed history of one of the oldest amateur societies in the United States. Printed by the photo-offset process, the book includes short biographies of many past and present officers.

Astronomy with an Opera-Glass, *Garrett P. Serviss,* 1961, *Chatham Press,* 811 Chatham St., Montreal 3, Que., Canada. 147 pages. $3.95.

Celestial objects accessible each season through binoculars are described and located on charts in this classic little book for beginners in observing. First published in 1888 and long out of print, it has been revised by Edwin E. Bridgen of the Montreal Centre, Royal Astronomical Society of Canada.

The Planet Venus, *Patrick Moore,* 1961, *Faber and Faber Ltd.,* 24 Russell Square, London W.C.1, England. 151 pages. 18s.

This third edition of a popular work has been extensively revised since its first publication in 1956. Its author, a well-known British amateur astronomer, supplements with extensive reference lists his illustrated descriptions of such topics as the observational history, markings, atmosphere, motions, and rotation of Venus.

The Hubble Atlas of Galaxies, *Allan Sandage,* 1961, *Carnegie Institution of Washington,* Washington, D. C. 132 pages. $10.00.

Plans left by Edwin P. Hubble at his death in 1953 for an atlas defining and illustrating his system for the classification of galaxies have now been realized. Descriptions of the various classes are followed by 50 double-size pages of plates containing Mount Wilson and Palomar Observatories' photographs of 176 external systems. Exposure data and other information are given for each picture.

CORRECTION

Referring to his review of *Planets, Stars, and Galaxies* by Stuart Inglis (July issue, page 39), Dr. Thornton Page wishes to modify his Chapter 3 description where it concerns the proton-proton reaction and the carbon cycle. Actually, no attempt is made to cover these subjects in that chapter, where they are used only as examples. Both processes are, however, considered in detail in Chapter 9, along with a discussion of solar energy generation.

The "glossary" mentioned in the review's last paragraph consists of word lists found at the end of each chapter.

Planetarium Notes

(Most planetariums give group and special showings by appointment.)

CALIFORNIA

Los Angeles
Griffith Observatory and Planetarium
Griffith Park, P. O. Box 27787, Los Feliz Station (27). NO 4-1191. Director, C. H. Cleminshaw.
SCHEDULE: Daily (except Monday), 3 and 8:30 p.m.; also 1:30 and 4:30 p.m. Saturday and Sunday. Zeiss projector.

San Francisco
Morrison Planetarium
California Academy of Sciences, Golden Gate Park (18). BA 1-5100. Curator, George W. Bunton.
SCHEDULE: Daily (except Monday and Tuesday), 3:30 and 8:30 p.m.; also 2 p.m. Saturday and Sunday. Tuesday, 3:30 p.m. Academy projector.

San Jose
Rosicrucian Planetarium and Science Museum
Park and Naglee Aves. Director, Rodman R. Clayson.
SCHEDULE: Sunday and Wednesday, 2 and 3:30 p.m. Spitz projector.

Santa Barbara
Gladwin Planetarium
Museum of Natural History, 2559 Puesta del Sol Rd. WO 6-6720. Lecturer, C. Adair.
SCHEDULE: 1st and 3rd Monday, 3 p.m.; 2nd and 4th Thursday, 8 p.m. Admission free. Spitz projector.

COLORADO

Colorado Springs
Academy Planetarium
U. S. Air Force Academy. GR 2-2779. Director, Maj. Wallace E. Moore.
SCHEDULE: Wednesday, 8 p.m.; Saturday, 2:30 p.m.; Sunday, 2 and 3:15 p.m. Admission free. Spitz Model B projector.

Denver
Denver Museum of Natural History Planetarium
City Park. EA 2-1808. Curator, Robert E. Samples.
SCHEDULE: Weekdays, 3:00 p.m.; also 12:30, 1:30, and 2:30 p.m. Saturday and Sunday. Spitz projector.

CONNECTICUT

Mystic Seaport
Seaport Planetarium
Marine Historical Association. JE 6-2631. Director, Frederic W. Keator.
SCHEDULE: Daily, 2 and 4 p.m.; also noon Saturday and Sunday. Spitz projector.

Stamford
Edgerton Planetarium
Stamford Museum and Nature Center. DA 2-1646. Director, Ernest T. Luhde.
SCHEDULE: Saturday, 11 a.m. and 3:15 p.m.; Sunday, 4 p.m. Spitz projector.

FLORIDA

St. Petersburg
St. Petersburg Junior College Planetarium
St. Petersburg Junior College (10). Director, Elizabeth James.
SCHEDULE: Monday, 7:30 p.m. (except school holidays). Spitz projector.

ILLINOIS

Chicago
Adler Planetarium
900 E. Achsah Bond Dr. (5). WA 2-1428. Director, Robert I. Johnson.
SCHEDULE: Monday through Friday, 11 a.m. and 3 p.m.; also 7:30 p.m. Tuesday and Friday. 10 a.m. Tuesday through Friday (special school program). Saturday and Sunday, 12:30, 2, and 3:30 p.m.; Saturday, 11 a.m. (special children's show). Zeiss projector.

INDIANA

Evansville
Koch Planetarium
Evansville Museum of Arts and Sciences, Sunset Park. HA 5-2406. Curator of education, James Gillinan.
SCHEDULE: Sunday, 2, 3, and 4 p.m. Spitz projector.

Indianapolis
Holcomb Planetarium
Butler University (7). AT 3-1340. Director, Harry E. Crull.
SCHEDULE: Saturday and Sunday, 4 and 8 p.m. Spitz projector.

IOWA

Cherokee
Sanford Museum and Planetarium
117 E. Willow. CA 5-3922. Director, W. D. Frankforter.
SCHEDULE: By appointment daily (except Sunday) during museum hours. Spitz projector.

Waterloo
Theater of the Stars
Grout Historical Museum, Park Ave. at South St. AD 4-6357. Director, Genevieve Woodbridge.
SCHEDULE: Saturday, 2:30 p.m. Admission free. Spitz projector.

MARYLAND

Baltimore
Davis Planetarium
Maryland Academy of Sciences, Enoch Pratt Library Bldg., 400 Cathedral St. (1). MU 5-2370. Director, Paul S. Watson.
SCHEDULE: (Sept.-June) Thursday, 7:15, 7:45, 9 p.m.; Saturday, 2 and 3 p.m. Admission free. Spitz projector.

MASSACHUSETTS

Boston
Charles Hayden Planetarium
Museum of Science, Science Park (14). RI 2-1410. Director, John Patterson.
SCHEDULE: Tuesday through Friday, 11 a.m. and 3 p.m.; Friday, 8 p.m.; Saturday, 11 a.m., 2 and 3:30 p.m.; Sunday, 1:30, 2:45, and 4 p.m. Korkosz projector.

Springfield
Seymour Planetarium
Springfield Science Museum (3). Director, F. D. Korkosz.
SCHEDULE: Tuesday, Thursday, Saturday, and Sunday, 3 p.m.; also 8:30 p.m. Tuesday; 2 p.m. Saturday, special star stories for children. Admission free. Korkosz projector.

MICHIGAN

Bloomfield Hills
McMath Planetarium
Cranbrook Institute of Science.
SCHEDULE: Wednesday, 4 p.m.; Saturday and Sunday, 2:30 and 3:30 p.m. Spitz projector.

Flint
Robert T. Longway Planetarium
Flint Junior College, 1310 E. Kearsley St. (3). CE 8-1631. Director, Maurice G. Moore.
SCHEDULE: Tuesday, Thursday, Friday, and Saturday, 8 p.m.; Saturday and Sunday, 2 p.m. Spitz Model B projector.

MINNESOTA

Minneapolis
Science Museum
Minneapolis Public Library, 300 Nicollet Ave. (1). Planetarium director, Mrs. Maxine B. Haarstick.
SCHEDULE: Saturday and Sunday, 2, 3, and 4 p.m.; also 10 and 11 a.m. Saturday. Admission free. Spitz Model C projector.

MISSOURI

Kansas City
Kansas City Museum Planetarium
3218 Gladstone Blvd. (23). HU 3-8000. Director, Wilber E. Phillips.
SCHEDULE: Saturday and Sunday, 3 p.m. Spitz projector.

Laquey
Tarbell Planetarium
Inca Cave Park, Highway 66. Director, E. D. Tarbell.
SCHEDULE: Half-hour shows daily 10 a.m. to 6 p.m. Spitz projector.

NEBRASKA

Hastings
McDonald Planetarium
Hastings Museum. Supervisor, Lawrence E. Brown.
SCHEDULE: Daily, 3:30 p.m.; also 2 p.m. Saturday and Sunday. Spitz projector.

Lincoln
Ralph Mueller Planetarium
University of Nebraska State Museum (8). HE 2-7631. Co-ordinator, John A. Howe.
SCHEDULE: (mid-Sept.-May) Wednesday, 8 p.m.; Saturday, 2:45 p.m.; Sunday, 2:30 and 3:45 p.m. Spitz projector.

NEW JERSEY

Newark
Newark Museum Planetarium
49 Washington St. (1). MI 2-0011. Supervisor, Raymond J. Stein.
SCHEDULE: Saturday, Sunday (except 1st Sunday of month), and holidays, 2:30 and 3:30 p.m. Admission free. Spitz projector.

NEW YORK

New York City
American Museum-Hayden Planetarium
81st St. and Central Park West (24). TR 3-1300. Chairman, J. M. Chamberlain.
SCHEDULE: Monday, 2 and 3:30 p.m.; Tuesday through Friday, 2, 3:30, and 8:30 p.m.; Saturday, 11 a.m., 1, 2, 3, 4, 5, and 8:30 p.m.; Sunday and holidays, 1, 2, 3, 4, 5, and 8:30 p.m. Zeiss projector.

NORTH CAROLINA

Chapel Hill
Morehead Planetarium
University of North Carolina. Director, A. F. Jenzano.
SCHEDULE: Daily, 8:30 p.m.; also 11 a.m. and 3 p.m. Saturday, 3 and 4 p.m. Sunday. Zeiss projector.

OHIO

Dayton
Dayton Museum of Natural History Planetarium
2629 Ridge Ave. (14). CR 5-7432. Curator, William E. Buvinger.
SCHEDULE: Tuesday and Friday, 7:30 p.m.; Saturday and Sunday, 2:30 and 4:00 p.m. Spitz projector.

OREGON

Portland
Oregon Museum of Science and Industry
4015 S. W. Canyon Rd. (1). CA 6-4518. Planetarium director, Norman C. Smale.
SCHEDULE: Monday through Friday, 2:30 p.m.; Saturday, 2 and 3:30 p.m.; Sunday, 2, 3, and 4 p.m. Spitz projector.

PENNSYLVANIA

Lancaster
North Museum and Planetarium
Franklin and Marshall College. Curator, John W. Price.
SCHEDULE: Tuesday and Thursday, 8 p.m.; Saturday and Sunday, 2 and 3 p.m.; Monday, Wednesday, and Friday, 9:15 and 10:15 a.m. (special school program). Admission free. Spitz projector.

Philadelphia
Fels Planetarium
Franklin Institute, 20th St. at Benjamin Franklin Parkway (3). LO 4-3600. Director, I. M. Levitt.
SCHEDULE: Monday through Friday, 12 and 3 p.m.; also Wednesday and Friday, 8 p.m.; Saturday, 11 a.m.; Saturday and Sunday, 2 and 3 p.m.; Sunday, 4 p.m. Zeiss projector.

Pittsburgh
Buhl Planetarium and Institute of Popular Science
Federal and W. Ohio Sts. (12). FA 1-4300. Program director, Arthur L. Draper.
SCHEDULE: Daily, 2:15 and 8:30 p.m.; also 11:15 a.m. Saturday, 4:15 p.m. Sunday. Zeiss projector.

RHODE ISLAND

Providence
Roger Williams Planetarium
Roger Williams Park Museum (5). WI 1-5640. Director, Maribelle Cormack.
SCHEDULE: (Oct.-May) Saturday, 3:30 p.m.; Sunday and holidays, 3 and 4 p.m. Admission free. Spitz projector.

TENNESSEE

Chattanooga
Clarence T. Jones Observatory
University of Chattanooga, Brainerd Rd. MA 2-5733. Astronomer in charge, Karel Hujer.
SCHEDULE: Friday, 8 p.m. Admission free. Jones projector.

Memphis
Memphis Museum
233 Tilton Rd. at Central Ave., Chickasaw Gardens (11). GL 2-4732. Director, Mrs. Ruth C. Bush.
SCHEDULE: Saturday and Sunday, 2 and 2:45 p.m.; also 3:30 p.m. Sunday. Admission free. Spitz projector.

Nashville
Sudekum Planetarium
Children's Museum, 724 2nd Ave. S. (10). CH 2-1858. Director, Jacqueline Avent.
SCHEDULE: Sunday, 2:45, 3:30, and 4:15 p.m. Spitz projector.

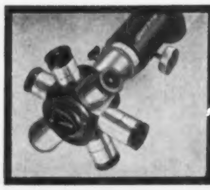
TEXAS

Dallas
Dallas Planetarium
Dallas Health and Science Museum, Fair Park (10). HA 8-8351. Director, H. D. Carmichael.
SCHEDULE: Saturday and Sunday, 3 p.m. Spitz projector.

Fort Worth
Charlie M. Noble Planetarium
Fort Worth Children's Museum, 1501 Montgomery. PE 2-1461. Supervisor, Norman C. Cole.
SCHEDULE: Saturday and Sunday, 2:30 and 3:30 p.m.; also 11 a.m. Saturday. Spitz projector.

WEST VIRGINIA

Charleston
Hillis Townsend Planetarium
Children's Museum, Public Library Bldg. Director, Mrs. R. L. Sullivan.
SCHEDULE: Saturday, 11 a.m. Admission free. Spitz projector.



UNITRON

MONTHLY REPORT TO OBSERVERS

SEE THE BACK COVER FOR MORE NEWS ABOUT *UNITRON*

constellation of the month

PEGASUS

A famous star pattern coming up the eastern sky on clear September evenings is the Great Square in Pegasus. During the World Series next month, this feature is apt to be called a celestial baseball diamond.

Any naked-eye sky watcher beginning to learn the fall constellations can make an easy start with this large and striking pattern of four bright stars, one of them shared with neighboring Andromeda. With the help of a star map, it is a simple matter to trace the outlying parts of Pegasus, so extensive that the Flying Horse ranks seventh in size among the constellations.

For the owner of a newly acquired UNITRON, too, Pegasus is a good starting point for deep-sky explorations. Calling for first attention in any refractor from 1.6-inch aperture up is the fine globular cluster Messier 15, readily found a few degrees northwest of Epsilon Pegasi (Enif). This magnificent object appears as a large but compact ball of soft light, whose glow comes from myriads of faint, unresolved stars.

After examining this cluster, take a second look at 3rd-magnitude Epsilon itself. It has a distant 8th-magnitude companion about 140 seconds of arc to the northwest. Pegasus abounds in wide double stars, favored by many amateur telescope users because they can be enjoyed with convenient, low powers on any clear night. Very close doubles, on the other hand, require those rare nights when the air is very steady.

Some other Pegasus stars with companions between magnitudes 7 and 10, at distances from 90 seconds down to 12, are Eta, Kappa, 1, 3, and 57 Pegasi. All of these rank as very easy to fairly easy with a 3-inch UNITRON.

Amateur observers of variable stars know Pegasus as a region rich in objects of changing brightness. Though only one variable in this constellation (Beta) can be followed with the unaided eye, about 20 are bright enough for a 2.4-inch UNITRON, and there are nearly 50 within reach of a 4-inch. The superior light grasp of a 6-inch UNITRON gives an even wider choice to the variable star enthusiast.

To the newcomer and more experienced astronomer alike, the choice of "the best" telescope is difficult and confusing . . . so many makes . . . so many models. An astronomical telescope must be designed to observe "point sources at infinity," and hence requires a precision optical system for crystal-clear definition. Optics and mountings must be equally precise to track the star or planet. One without the other is useless. Invest in a UNITRON and be certain of combined optical and mechanical excellence.

MANY Models To Choose From!

1.6" ALTAZIMUTH ($7.50 Down) **$75**
with eyepieces for 78x, 56x, 39x

2.4" ALTAZIMUTH ($12.50 Down) **$125**
with eyepieces for 100x, 72x, 50x, 35x

2.4" EQUATORIAL ($22.50 Down) **$225**
with eyepieces for 129x, 100x, 72x, 50x, 35x

3" ALTAZIMUTH ($26.50 Down) **$265**
with eyepieces for 171x, 131x, 96x, 67x, 48x

3" EQUATORIAL ($43.50 Down) **$435**
with eyepieces for 200x, 131x, 96x, 67x, 48x

3" PHOTO-EQUATORIAL ($55.00 Down) **$550**
with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x

4" ALTAZIMUTH ($46.50 Down) with **$465**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

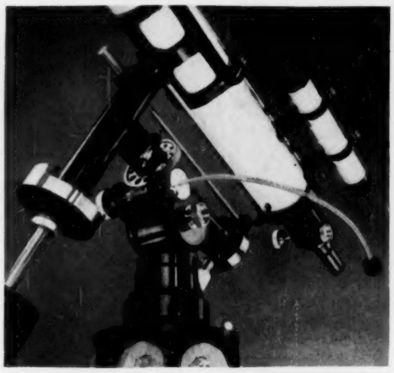
4" EQUATORIAL ($78.50 Down) with **$785**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" EQUATORIAL with clock drive **$985**
($98.50 Down), Model 160V, eyepieces as above

4" PHOTO-EQUATORIAL with clock drive and **$1175**
Astro-camera **($117.50 Down)**, eyepieces
for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

4" PHOTO-EQUATORIAL with clock drive, pier, **$1280**
Astro-camera **($128.00 Down)**, eyepieces for 375x,
300x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

6" EQUATORIAL with clock drive, pier, **$5125**
2.4" view finder, eyepieces for 625x, 500x,
416x, 357x, 277x, 200x, 138x, 100x, 62x, 42x



UNITRON of the month

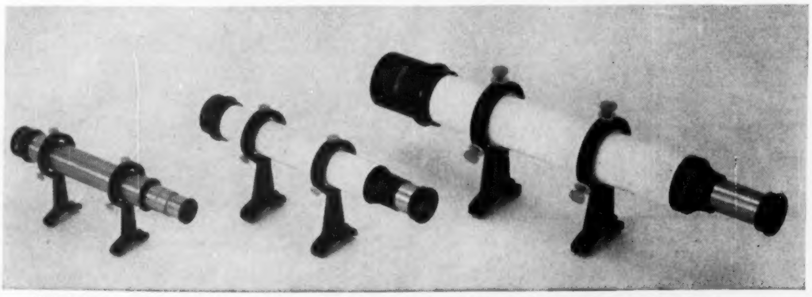
4-INCH EQUATORIAL

To judge by our mail, a significant percentage of UNITRON owners seem to divide their time between observing the heavens and praising the performance of their telescopes. This behavior pattern is especially noticeable in the case of those fortunate enough to own a 4-inch UNITRON. It is easy to get enthusiastic about the 4-inch, for new observing thrills await you each and every time.

UNITRON's Model 152, illustrated above, is our least expensive 4-inch equatorial model. The purchase price of $785 covers just about everything needed for serious observing. Standard-equipment accessories include the 10x 42-mm. view finder, Super rack-and-pinion focusing mechanism, UNIHEX Rotary Eyepiece Selector, seven eyepieces, achromatic amplifier, sunscreen, etc. The complete unit is designed for portable operation and takes but a jiffy to set up for use in the field.

Using UNITRON's easy payment plan, you, too, can own this professional 4-inch refractor for only $78.50 down. Be good to yourself . . . treat yourself to a UNITRON.

New UNITRON View Finders



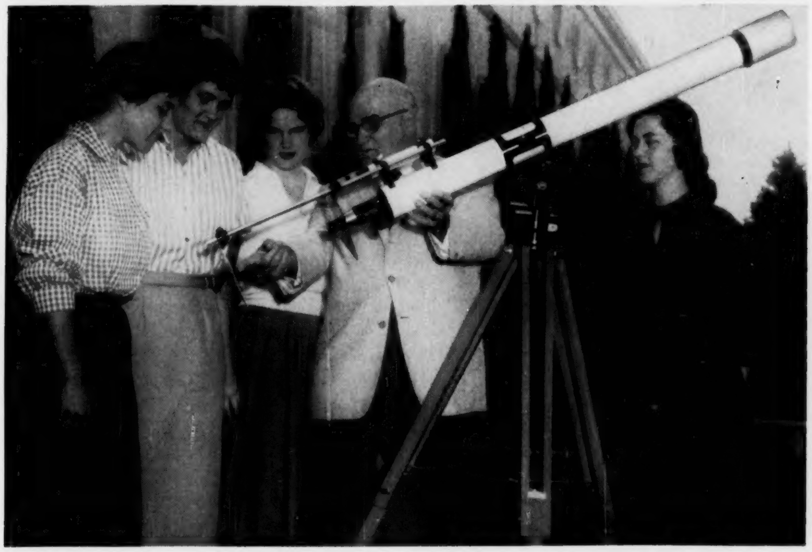
UNITRON's popular view finders with newly designed optics and mechanical features are better than ever. From left to right: 23.5 mm., 30 mm., 42 mm.

1. VIEW FINDER (Used on UNITRON 2.4" Equatorials): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws. **Only $8.50 postpaid**

2. VIEW FINDER (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3. **Only $10.75 postpaid**

3. VIEW FINDER (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duralumin tube finished in white enamel. Dewcap. Furnished with mounting brackets, centering screws for collimation, and mounting screws. This finder measures approximately 16" overall. It is light in weight, compact and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky. **Only $18.00 postpaid**

September Is Back-to-School Month . . . with UNITRON



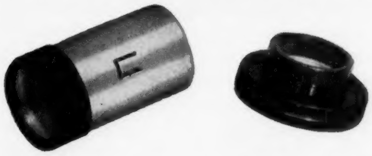
Seeing is believing. Students at the San Diego College for Women, San Diego, California, observe sunspots with their UNITRON 3-inch Altazimuth. Professor Randolph M. Lippert, F.R.A.S., of the department of astronomy provides the commentary.

In this space age, astronomy is regaining its rightful place in the school curriculum. But students deserve more than just an opportunity to read about the universe. Studies become more interesting and lectures more meaningful when students can *see* for themselves the planets of our solar system and other celestial wonders.

For this reason, an astronomical telescope is rapidly becoming an indispensable teaching aid for secondary schools and colleges throughout the country. And what telescope is "teacher's pet"? Why, none other than UNITRON — America's largest-selling refractor. UNITRONS are portable, easy to operate and, unlike other types, require no maintenance. They offer professional quality at prices well within the reach of even limited school budgets.

If your school is slow to accommodate its thinking to the space age, why not take the initiative yourself and recommend the purchase of a telescope to your local school board. Funds from the National Defense Education Act are now available for the purchase of science teaching equipment. With interest in astronomy at an all-time high there is no better moment than now to treat your students to a UNITRON. Keep pace with the space age. Invest in a UNITRON — the telescope with the proven reputation.

NEW ACHROMATIC AMPLIFIER NOW FREE with each UNITRON



UNITRON's new "Achromatic Amplifier" is a two-element, Barlow-type, negative amplifying lens designed especially for UNITRON Refractors. When used with a UNITRON eyepiece, it **doubles** the normal magnification of the telescope. Here is an ideal way to increase the usefulness of each eyepiece and to obtain the high magnifications that you have always wanted for planetary and lunar observations. The magnification factor of 2x has been selected as the most useful for general amateur observing under a wide variety of atmospheric conditions. Two types of mounting cells are offered: one to fit the UNIHEX Rotary Eyepiece Selector and one for the UNITRON Star Diagonal. Either type can be inserted or removed in a jiffy. There are no cumbersome tubes to attach, nor ever any need to adjust the focus of the "Achromatic Amplifier."

This useful and valuable accessory is now included as standard equipment with all UNITRON Refractors at no additional cost . . . another of the many reasons why the telescope you choose should be a UNITRON.

HOW TO ORDER A UNITRON

Send check or money order in full or use our Easy Payment Plan. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back. Prices of UNITRON refractors include basic accessories, eyepieces, tripod and mounting, fitted cabinets, and instructions.

USE OUR EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is cancelled.

Note These UNITRON Features

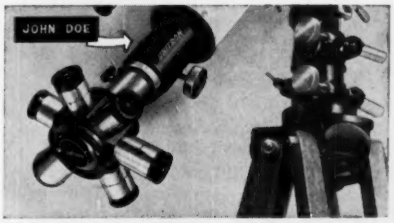
- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to ten eyepieces included with each instrument.
- FINEST MATERIALS used throughout. DURALUMIN TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for **both** declination and right ascension as well as convenient clamps on both axes. Sturdy TRIPOD (or PIER).
- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.
- VIEW FINDER with crosshair eyepiece.
- RACK-AND-PINION FOCUSING.
- Choice of UNIHEX Rotary Eyepiece Selector or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The same complete range of terrestrial magnifications as for celestial observation.

Higher- and lower-power eyepieces available for all models. Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions.

CALLING ALL UNITRON OWNERS!

If you purchased a UNITRON before the Achromatic Amplifier was available, we want you to have the chance to get one, and offer it at the special price of $6.00 — less than one-third the price you'd pay elsewhere for an accessory of this quality. This offer is for UNITRON owners only. (When ordering, please state whether for UNIHEX or star diagonal.)

IT HAD TO HAPPEN: A UNITRON WITH YOUR NAME ON IT!



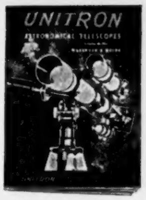
We've gone and done it. We've personalized the telescope business. For a limited time, when you buy a **UNITRON,** you can have your name embossed in a plastic name plate attached to the gleaming black barrel at no charge.

People tell us they like it. It's in quiet good taste, yet it seems to give that extra fillip to the pride of ownership people feel for their UNITRONS. To get your name plate simply add this statement to your order: Please attach a name plate to my telescope. This is the name: (print name clearly).

Get UNITRON's FREE Observer's Guide and Catalog

Contents include:

- Observing the sun, moon, planets and wonders of the sky
- Constellation map
- Hints for observers
- Glossary of telescope terms
- How to choose a telescope
- Amateur clubs and research programs



UNITRON

INSTRUMENT COMPANY • TELESCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush to me, free of charge, UNITRON'S new Observer's Guide and Telescope Catalog **20-T.**

NAME ____________________

STREET ____________________

CITY ____________ STATE ____________

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

A Simple Aluminum Camera Support

AMATEURS who have no machine shops or easy access to steel supplies and aluminum foundries find many build-it-yourself items interesting but unattainable. My camera adapter requires only a hacksaw, hand drill, file, and screwdriver for construction, and most of the material is available at local hardware stores. It is solid, inexpensive, and versatile enough to adapt to a telescope almost any camera, simple photocell equipment, a solar projection screen, or a spectroscope. Total cost for the support, including screws and nuts, came to $5.84.

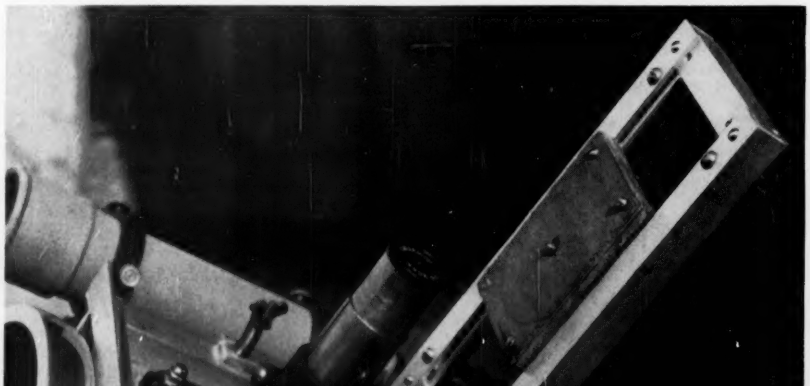
The complete unit has three parts: a base track fastened solidly to the telescope with two small machine screws, a camera-mount track that slides along the base track using simple spring-loaded retainers for clamping, and the camera mount itself. Track lengths can be altered to suit the user's convenience. The support was designed for a 7"-outer-diameter tube, but a spacer between telescope and base at the fastening would ensure solid fit for a larger size.

Aluminum is used for all parts except the camera mount, which is a block of plywood ½" thick and 4" by about 2-13/16". The advantage of aluminum is that it is easy to saw and drill, and requires no finishing beyond filing saw cuts smooth and removing burrs from drilled holes. Almost all the pieces are of ¾" by ¾" by ⅛" angle stock cut to proper lengths. The only other part required is a standard 4" by 4" by 2" aluminum radio utility cabinet with removable top and bottom. This can be found at local radio supply stores.

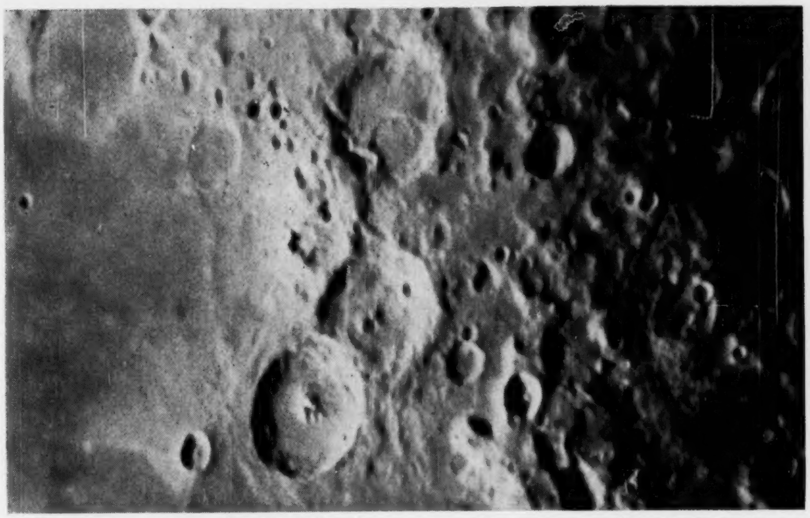
Buy eight #10-24 machine screws 1¾" long, with washers and wing nuts to fit, and eight springs the same length that will just slip over the screws. Screws and nuts also needed are 26 #6-32 ½" long for assembly, four #6-32 ¾" long for the camera mount, and one ¼-20 ¾" long to fit the camera's tripod threads. Other pieces can be made from aluminum scraps.

For the base track cut two 14" lengths of angle stock and two cross braces 5-13/16" long; also cut two 10" lengths for retainers. Drill holes near the ends of all pieces and in the centers of the cross braces. Fasten the ends of the long tracks to the cross braces as shown in the picture. Make four spacers by filing down to 3/32" thickness one side of a short length of angle stock, drilling holes at about ½" intervals, and cutting out ⅝" square pieces around each hole. Separated from the base track by these spacers, the retainers are held firmly in position by the #10-24 screws with their springs, washers, and wing nuts.

The foundation of the camera-mount



Wayne Norton's easily fabricated camera mount in position on his telescope. Two-way adjustment permits use of many different accessories.



Using a twin-lens reflex Rolleicord camera on the mounting described in this article, Mr. Norton photographed Mare Nectaris and the region east of it through his electrically driven 6-inch f/9 reflector and a 9-mm. eyepiece. His exposure was ½ second on Kodak Plus-X film. South is at the top, and the enlargement of this portion of the negative is about seven times.

track is the radio utility cabinet. Cut two 2″ lengths of angle stock for corner braces, two 11″ lengths for the track, two 8-3/16″ lengths for the retainers, and one cross brace 4-1/16″ long. The slide at the base of this piece consists of two 4¼″ lengths of angle stock with two 2¾″ lengths as guides.

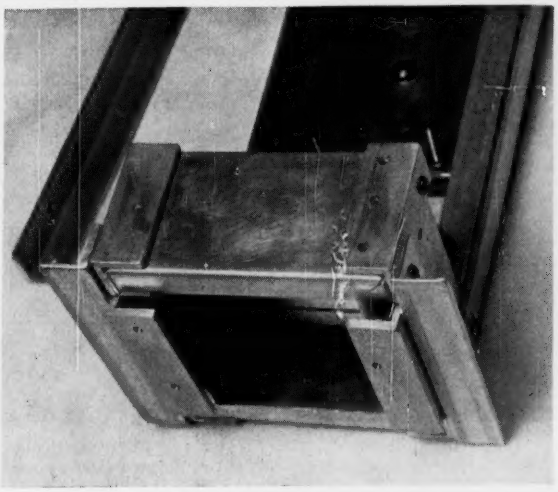
The close-up view of the track's base shows how the two corner braces, slides (with lips facing out), and guides (lips facing inward) are fastened to the box. Round off the leading edges of the sliding pieces to prevent their digging into the track. If necessary to insure a snug fit, thin sheet aluminum can be used to shim these pieces out. The track and retainers are fastened together in the same way as for the base track, except that the retainers are placed inside the uprights. Spacers are made by removing ⅞″ from one side of the top or bottom plate of the utility box, the remainder measuring 3″ by 3⅞″. This forms the slide for the camera mount. File down the ⅞″ piece to about 3/64″ thickness, drill four holes, and saw ⅝″ squares just as for the base spacers.

To insert the camera-mount track into the base track, remove one retainer, slip the assembly's slide into the space between track and retainer on the other side, and replace the retainer that was removed. Cut clearance holes for the camera screw in the center of the cut-down utility-box top and in the block of plywood. Fasten the two pieces together so that the central holes line up and the wide dimension of the box top protrudes beyond the narrow dimension of the plywood, forming a slide for the camera mount. Round off the leading edges of the slide, insert it in the camera-mount track using the spring nuts to lock it in position, and the assembly is complete.

Finally, mount the camera on the assembly and position the base track along the tube until the camera lens is directly over the eyepiece. Drill holes in the tube under the central cross-brace holes, and fasten the track with small screws. The angle pieces forming the track straddle the tube nicely and make a very solid construction. As I built it, the adapter allows 4½″ movement parallel to the optical axis and 3½″ toward and away from the eyepiece. It requires compensating the balance of tube and mounting, just as any other added weight would.

I have used this adapter for about a year with many types of auxiliary equipment and have not exhausted its possibilities. Some amateurs might prefer to have a rack-and-pinion control on each track; these could be added without difficulty.

WAYNE L. NORTON
R. R. #1
Ridgeville, Ind.



The base of the sliding accessory mount, showing the angle pieces that move along the fixed track on the telescope tube. Inserted between the right inside guide rail and the aluminum utility box is a shim used to assure snug fit. The only component of the mount not of aluminum is the wooden camera platform. All photographs with this article are by the author.

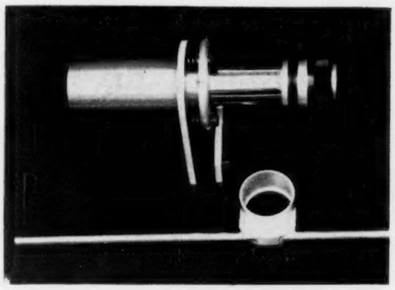
SEEING is so poor in our neighborhood that telescopes have to be portable and used in the nearby mountains. Observing with setting circles has always been a problem, as it takes too long to set the polar axis on true north. My neighbor Dick Meyers solved this difficulty, however, by developing a polar axis aligner for his newly built 8-inch reflector.

The device is a modified finder scope that has mutually perpendicular cross wires. The finder is clamped on the tube by some arrangement such as Mr. Meyers' spring-loaded assembly, so that it can be aligned with the telescope's optical axis.

To the finder's reticle must be added another wire parallel to one of the crosshairs and far enough off center for the separation to appear the same as Polaris' distance from the pole, when the perpendicular reference wire is set along the line joining that star and the pole. Fortunately, both Alkaid (the star at the end of the dipper handle) and Epsilon Cassiopeiae (the star at the lower end of the W when Cassiopeia is rising) also lie along this line, and one or the other is usually conveniently placed on any given night.

The distance to set the wire on the reticle is found by multiplying the focal length of the finder objective by 0.016, based on Polaris' present distance of 55 minutes of arc from the pole, which will change by less than a minute over the next three or four years. The eyepiece containing this reticle (or the whole assembly) must be rotatable so the reference wire can be set.

Clamp the pole finder on the tube and align its optical axis by centering any star in the main telescope and adjusting the unit until the star is also at the intersection of the original crosshairs. Next, by eye estimation set the polar axis toward the north, turn the declination axis until it is horizontal, and sight Polaris in the pole finder. Rotate the eyepiece until the reference wire points to Alkaid or Epsilon Cassiopeiae, with the off-center wire nearer to Cassiopeia. Then move the entire mounting (or the equatorial head, if it can be moved separately) until the off-center wire is on Polaris. The central wires then cross at the pole and the telescope is aimed in azimuth at true north. (If this is done at a time when Polaris happens to be directly above or below the pole, the azimuth of the mounting will not have to be changed after the star is set on the crosshairs.)



Dick Meyers' pole finder is set parallel to his telescope's optical axis with three spring-loaded bolts. The device in the foreground is used by Gordon Konstanzer (see facing picture).

Now set the declination axis so that the tube is over the polar axis and parallel to it. Again set the reference wire toward Alkaid or Epsilon Cassiopeiae and, without changing azimuth, adjust the north end of the polar axis until Polaris ap-

Using his pole finder, Mr. Meyers can align the polar axis of his reflector on true north in only a few minutes each time he sets it up.

Mr. Konstanzer rotates his telescope tube until the bar on the finder eyepiece points to Alkaid. The instrument then can be set to true north.

pears at the intersection of the reference and off-center wires. To allow for any slight displacement, set the declination axis horizontal again and repeat the first step.

With a little practice this routine can be performed very quickly and the telescope lined up almost perfectly. The device is accurate enough that by means of the setting circles any object can be brought into the finder, and most of the time it is also found in the field of a low-power ocular on the main instrument.

The telescope's regular finder can double as a pole finder if the off-center line is added to the reticle and the eyepiece is made rotatable. It is also possible to use the telescope's rotating tube (if it has one) to set the reference wire, instead of turning the eyepiece. In this case, it is better to have an off-center wire on each side of the central wire for convenience in setting.

My own telescope has a right-angle finder. The reference wire is at right angles to the tube, with the other wires parallel. By sighting along the top flange of the finder's eyepiece, I can rotate the tube to line up the reference wire. To help in this I soldered a rod on each side of a ring, which forms an extension of the reference wire when slipped over the eyepiece. This, of course, can only be used with a rotating tube, since the rod would interfere with a rotating eyepiece.

I decided to make the off-center lines on my reticle with a stick diamond, but no matter how lightly I pressed, the cut lines look like ropes. However, they work well and are far enough off center that they do not interfere with the instrument's use as a finder.

GORDON KONSTANZER
2735 Milan Court
Los Angeles 41, Calif.

A Foucault Light Source from a Flashlight Bulb

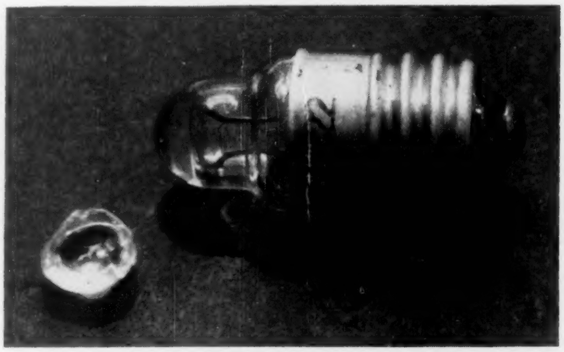
In 1955 George Random of the Boston University Optical Research Laboratory introduced one of the most compact, practical light sources for optical tests that I have used. With a diameter of ½" and a length no more than 1½", the unit causes no serious silhouetting of the central area of an assembly when placed on its optical axis. It is also useful for autocollimation and conjugate-foci null testing of mirrors.

The bulb – heart of the light source – is a standard penlight type that tapers to a tiny lens at its tip. Illustrated is a GE 222, which is available at hardware stores. The bulbs must be carefully examined with a low-power magnifier to be sure that the filament runs straight through the center of the lens, as viewed from in front. It does not matter if it curves forward and back, but it must not curve sideways. Buy three or four good bulbs for spares, and one or two bad ones. Break the lens off a bad bulb, to form the second element of a double-condenser focusing system.

Materials for the housing are listed opposite. Solid pieces have holes drilled in their centers, and pieces **4**, **7**, and **8** should fit into pieces **1** and **2** by pressure. All items are metal except **4**, which is phenolic plastic, bakelite, or some other nonconductor.

Cement piece **5** inside **3**, as illustrated, and then cement ⅛" of **3** into an end of **1**, to form the shoulder holding the light bulb. Now insert a bulb into the tube, centering and holding it with the nonconducting piece **4** at its base. Two lengths of spring brass bolted to this piece will serve as contacts, and wire may be run to a battery from the bolts.

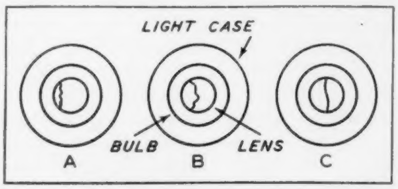
A close-up view of a General Electric 222 flashlight bulb, the type used in the Foucault light source described here. At left is a lens broken from another of these bulbs; it and the lens in the lamp together act as a compound condenser, giving a strong light on the tester's pinhole. Photo by R. E. Cox.



Cement the broken piece of lens into its retaining ring **6** with Duco cement or some equivalent. Insert it in piece **3** until it just touches the bulb, keeping it aligned squarely with the bulb lens.

To diffuse the light from the filament image, make a ground glass from a thin piece of glass, such as a microscope slide cover, by grinding both sides with fine emery. Cement a piece about ⅛" square over the hole in **7**.

For the slit, break a razor blade in half and cement sections of it, sharp sides facing, over the back of **8**, separating the edges only a few thousandths of an inch. A piece of cellophane or paper can be measured with a micrometer and used as a gauge for spacing.



Looking at a flashlight bulb from the top tells whether it is usable in the light source. The filament in A is offset too far; that in B is crooked; bulb C is nearly perfect.

Fit **7** and **8** into one end of piece 2 as shown, and slip the tube over the end of **3**. Light the bulb and focus the image of the filament on the ground glass as sharply as possible. The unit is now ready to use. The power supply should be only $1\frac{1}{2}$ to 2 volts, or the bulb will burn out quickly. Too bright a light is also hard on the eyes while testing.

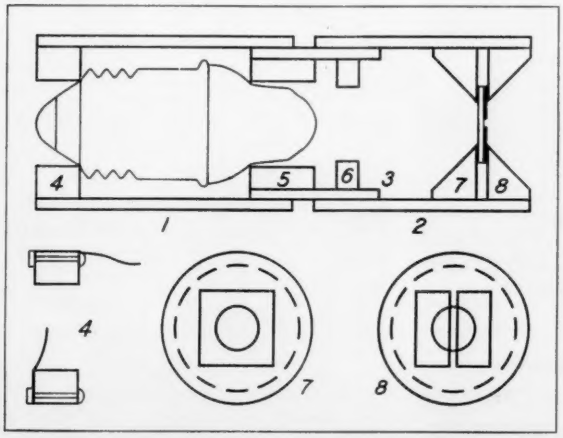
Adapting the light to various tests will be easier if several **8** pieces are made, with different slit widths, and with pinholes of various dimensions for point sources. Normally the filament is set parallel to the slit, though for wide-angle optics it should be at right angles. For this reason the support, a thin rod on a base, should be soldered to the bottom of piece **2**, so that the slit is always upright. It is then a simple matter to orient the filament by turning piece **1**.

Those with machine facilities and some ingenuity can make a more elaborate unit or refine the light source. Smaller bulbs of the type used are available, permitting a smaller unit to be designed around them.

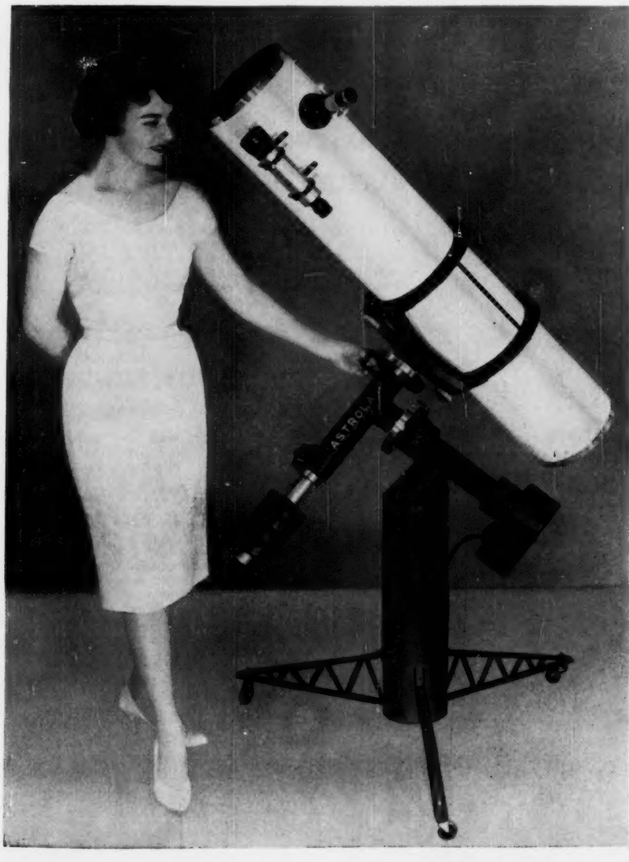
R. E. C.

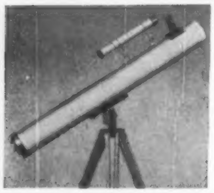
SPECIFICATIONS FOR FOUCAULT LIGHT SOURCE COMPONENTS

Piece	*Material*	*Length* (*inches*)	*Outer diameter* (*inches*)	*Wall thickness* (*inches*)	*Central hole size* (*inches*)
1	Tubing	3/4	1/2	1/32	
2	Tubing	5/8	1/2	1/32	
3	Tubing	3/8	7/16	1/32	
4	Solid round	1/8	7/16		1/4
5	Solid round	3/16	3/8		1/4
6	Solid round	1/16	3/8		#1 drill
7	Solid round	1/8	7/16		1/8
8	Solid round	1/8	7/16		1/8



A schematic view of the Foucault tester light source. Numbers in this diagram correspond to those in the table above. The scale is about 2:1. All parts are of metal except 4, which must be an insulator (phenolic plastic, for example). In the lower part of the drawing are details of the spring-brass contacts for the bulb base (4), the ground-glass holder (7), and the slit (8).





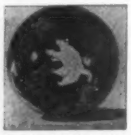
3-inch Astronomical Reflector

60 to 180 Power
An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60x eyepiece and a mounted Barlow lens, giving you 60 to 180 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

FREE with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."**

Stock #85,050-Y........................**$29.95 ppd.**



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Useful for the student beginning to study the stars, and the newly interested amateur. 12" heavy-gauge vinyl globe shows major constellations, with stars to 4th magnitude.

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7 x 50 BINOCULARS — TREMENDOUS BUY!

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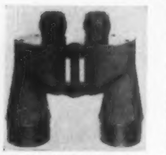

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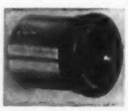
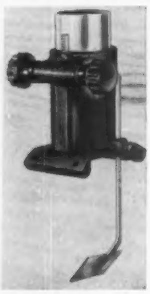
Wide, flat field — better correction under high magnification — excellent eye relief.



The orthoscopic eyepiece is one of the most important and best corrected eyepieces for astronomical work. These are of a four-element design, with coated lenses, and are standard 1¼" outer diameter, precision made of chrome-plated brass and aluminum.

Stock #30,364-Y	4 mm	**$14.50 ppd.**
Stock #30,404-Y	6 mm	**14.50 ppd.**
Stock #30,405-Y	12.5 mm	**14.50 ppd.**
Stock #30,406-Y	18 mm	**14.50 ppd.**
Stock #30,407-Y	25 mm	**14.50 ppd.**

Rack-&-Pinion Eyepiece Mounts

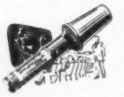


Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment. Lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors
Stock #50,077-Y..(less diagonal holder)....**$8.50 ppd.**
Stock #60,049-Y..(diagonal holder only).... **1.00 ppd.**
For Refractors
Stock #50,103-Y..(for 2⅞" I.D. tubing)...**$12.95 ppd.**
Stock #50,108-Y (for 3⅞" I.D. tubing)... **13.95 ppd.**

NEW LOW PRICE FLASHLIGHT POINTER

. . . Point It Out With Projected Arrow



Ideal for pointing to interesting features on movie and slide projection screens. Excellent lecture tool. For teacher use on maps, etc. Flashlight focuses an arrow where you point it.

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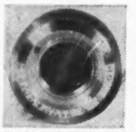

For only $5.95 you get a shutter worth much more. Speeds: Bulb, 1/25, 1/75, and 1/200th second. Iris diaphragm, 2 to 16 mm. Front threaded opening, 22-mm. diameter; rear threaded flange, 25-mm. diameter. Supplied with retaining ring.

Stock #70,423-Y........................**$5.95 ppd.**

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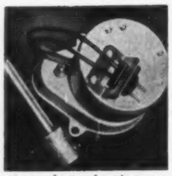

Excellent value for the serious amateur. With this motor you can make your own clock drive for about ⅓ the cost of a purchased one. Type 117-P Cramer motor (without clutch), left rotation, 1/15 r.p.m. 115 volts, 60 cycles, 2.7 watts, with a ⅜" shaft plus an extra 1½"-long shaft, setscrews, and directions for adapting to your telescope.

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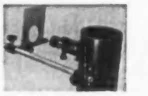
Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece, and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!



SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum; brackets black crinkle painted.

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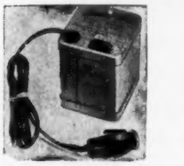
Fits any telescope; takes one size D flashlight battery. Case fastens to tripod leg with wing nut and clamp. Has two grain-of-wheat lamps and housings with 39" cords. One lamp rheostat controlled. By drilling a small hole in finder tube at the plane of the reticle, you can illuminate the crosshairs, controlling their brightness. Other lamp stays at constant brightness so you can illuminate your setting circles, check eyepieces, examine charts, or make notes.

Stock #50,219-Y........................**$2.95 ppd.**

Operate Your Clock Drive From a 12-Volt Auto Battery



These small inverters supply 110-volt, 60-cycle electricity from your car battery to operate your clock drive anywhere. (Can also be used to operate electric shaver.) 20-watt rating. Size: 2½" x 2½" x 3", 2 lbs.

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Set of 20 only $1.25

Custom-designed square-cross-section retaining rings provide far greater bearing surface than the usual round variety. Made of special carbon steel, these retaining rings really hold your lenses in position. Set includes four each of five different sizes: .618" O.D. x .035" sq.; .878" O.D. x .039" sq.; 1.136" O.D. x .055" sq.; 1.400" O.D. x .062" sq.; and 1.665" O.D. x .071" sq. Complete set provides superior results previously unobtainable, and fits practically all available tube sizes.

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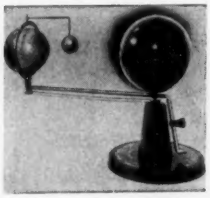

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Here is the story of cosmic motions — how the moon revolves around the earth, and the earth around the sun, with our planet rotating simultaneously. With this instrument, the observer sees a three-dimensional moving demonstration of how seasons, day and night, and moon phases occur. This handsome gear-and-chain-driven unit is supported by a smartly finished wood base. The sun is 6" in diameter, and the earth is 4". Planetarium stands 12" high, is 8" wide; arm is 18" long. A completely illustrated, delightfully informative handbook included.

Stock #70,415-Y........................**$29.95 ppd.**

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 2 holders, each with 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

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SUPER-STURDY MOUNT for Larger Telescopes

Finest new heavy-duty mount available. Specifically designed for 8" telescopes, commercial or amateur — also fine for 6" scopes. Can handle 10" reflector, refractors up to 5". Massive design, 1½"-diameter polar and declination axes. Cast-iron construction. Weight 75 lbs., including counterweights. Provides mass where most needed. Perfect balance. Fine adjustment for latitude setting. Positive shaft clamping, large bearing surfaces. Specially designed saddle for better tube rotation. Can be permanently mounted on standard 4" pipe. For professionals, serious amateurs, educational institutions. Aluminum setting circles available at extra cost. State mirror diameter when ordering. Shipping wt. 85 lbs.

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For many years, this achromatic coated Barlow lens has been the pride and joy of serious astronomers. Due to the death of the designer, Mr. Frank Goodwin, it has not been available for the past two years. NOW we can offer these lenses, in exact accordance with the original specifications. Remember, this Barlow is achromatic, coated, mounted in a blackened tube, and as optically perfect as only precision craftsmen can make it. Complete with instructions, in a 4"-long adapter tube for standard 1¼" eyepieces.

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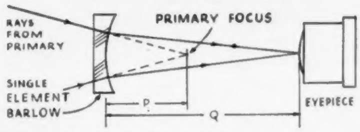
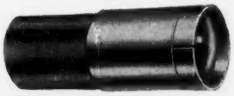


WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to very short-focal-length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

Stock #30,200-Y ... Mounted Barlow lens .... **$8.00 ppd.**

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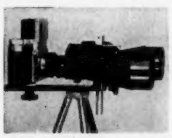
Will fit any camera



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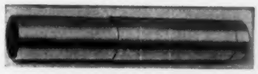

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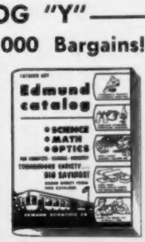

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CELESTIAL CALENDAR

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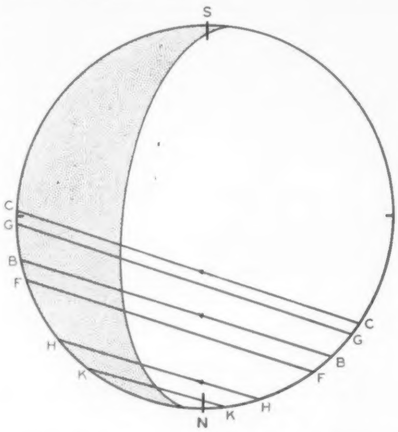
A Favorable Occultation of Aldebaran

OBSERVERS in all the continental United States except the Northwest will be able to view an occultation of Alpha Tauri by the 19-day-old gibbous moon on September 28-29, a Thursday night. In southern California moonrise occurs less than an hour before immersion takes place at the bright limb, but farther east both moon and star will be well up in the sky. Emersion will be particularly striking, as the orange 1st-magnitude star suddenly reappears in the darkness beyond the ellipse of the lunar terminator.

In the vicinity of San Francisco, and along a line running northeasterly across northern Nevada, Idaho, Montana, and North Dakota, a grazing occultation or close approach will be seen. Some observers may be located just right to watch Aldebaran disappear and reappear several times among the mountains at the moon's edge.

The diagram gives the star's apparent path behind the moon as seen from several occultation stations. Disappearance will occur at almost the same moment at stations **K** in California, **H** in Denver, and **F** in Illinois, though reappearance times at these locations are widely separated. Egress in California almost coincides with ingress at Montreal, as indicated by the predicted daylight saving times given in the table.

The position angle is counted around the moon's edge, eastward from the north point. For more information about this event, see the Occultation Supplement in the December, 1960, issue of Sky and Telescope. Data given there will permit amateurs in most parts of the United States to predict the times for their own localities.



This chart, with south at the top and east at the right, represents the telescopic appearance of the gibbous moon on September 28-29. Aldebaran's apparent path behind the moon is plotted for standard stations. For station A in Massachusetts the path is almost the same as for G in Texas, D is almost like B, and that of I is a little north of F. From data in the Occultation Supplement (December issue).

Station	*Location*	*Ingress*	*Position angle*	*Egress*	*Position angle*
A	Massachusetts	2:10.1 a.m. EDT	53°	3:23.3 a.m. EDT	273°
B	Montreal	2:16.3 a.m. EDT	43°	3:22.5 a.m. EDT	283°
C	Washington, D. C.	1:58.4 a.m. EDT	56°	3:12.1 a.m. EDT	268°
D	Toronto	2:07.7 a.m. EDT	41°	3:11.1 a.m. EDT	284°
F	Illinois	12:54.4 a.m. CDT	36°	1:49.9 a.m. CDT	289°
G	Texas	12:33.2 a.m. CDT	52°	1:34.0 a.m. CDT	272°
H	Denver	11:56.1 p.m. MDT	17°	12:30.5 a.m. MDT	310°
I	N. Mex.-Ariz.	11:41.7 p.m. MDT	31°	12:25.7 a.m. MDT	296°
K	California	10:55.1 p.m. PDT	6°	11:15.5 p.m. PDT	323°

MINIMA OF ALGOL

September 1, 16:58; 4, 13:47; 7, 10:35; 10, 7:24; 13, 4:13; 16, 1:02; 18, 21:50; 21, 18:39; 24, 15:28; 27, 12:16; 30, 9:05.

October 3, 5:54; 6, 2:43; 8, 23:32.

These minima predictions for Algol are based on a recent timing by D. Engelkemeir and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

VARIABLE STAR MAXIMA

September 6, RT Cygni, 194048, 7.3; 7, T Centauri, 1336**33**, 5.5; 17, T Camelopardalis, 043065, 8.0; 17, T Herculis, 180531, 8.0; 20, V Monocerotis, 0617**02**, 7.0; 27, RR Scorpii, 1650**30**, 5.9; 29, RU Sagittarii, 1951**42**, 7.2.

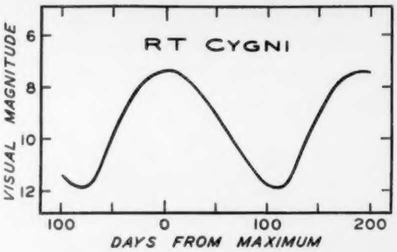
October 9, W Lyrae, 181136, 7.9.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the date given. The data include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MOON PHASES AND DISTANCES

Last quarter	September 1, 23:06
New moon	September 10, 2:50
First quarter	September 17, 20:24
Full moon	September 24, 11:34
Last quarter	October 1, 14:10

September	**Distance**	**Diameter**
Apogee 7, 20^h	252,400 mi.	29′ 25″
Perigee 23, 4^h	223,500 mi.	33′ 13″
October		
Apogee 5, 8^h	251,900 mi.	29′ 29″



The mean light curve of RT Cygni, plotted by Leon Campbell from observations by members of the American Association of Variable Star Observers.

RT CYGNI

LOCATED near the meridian during the evening hours this month is RT Cygni, a fairly bright long-period variable. It is plotted in both Norton's *Star Atlas* and the Skalnate Pleso *Atlas of the Heavens* about four degrees north of Delta Cygni, its 1950 co-ordinates being $19^h\ 42^m.2$, $+48°\ 39'$. RT has a mean period of 190 days, so in most years there are two maxima. The star is expected to come to maximum light, near magnitude 7.3, about September 6th.

The light curve is not quite symmetrical, the rise to maximum being slightly steeper than the decline. The maxima are wider than the minima. Average limits for the light range of this Mira-type variable are magnitudes 7.3 and 11.8, but the star has been as bright as 6.4 and as faint as 12.7. Its spectral class varies from *M*2e to *M*4e, and it was an inspection of the spectrum in 1890 that first led Mrs. W. P. Fleming at Harvard Observatory to suspect the star's variability in brightness.

RT Cygni is only 11 degrees from the plane of the Milky Way. There are no bright stars nearby, but this red star can be found differentially with setting circles by centering Delta Cygni in the field and then turning the telescope $1^m.2$ west and 3° 39′ north.

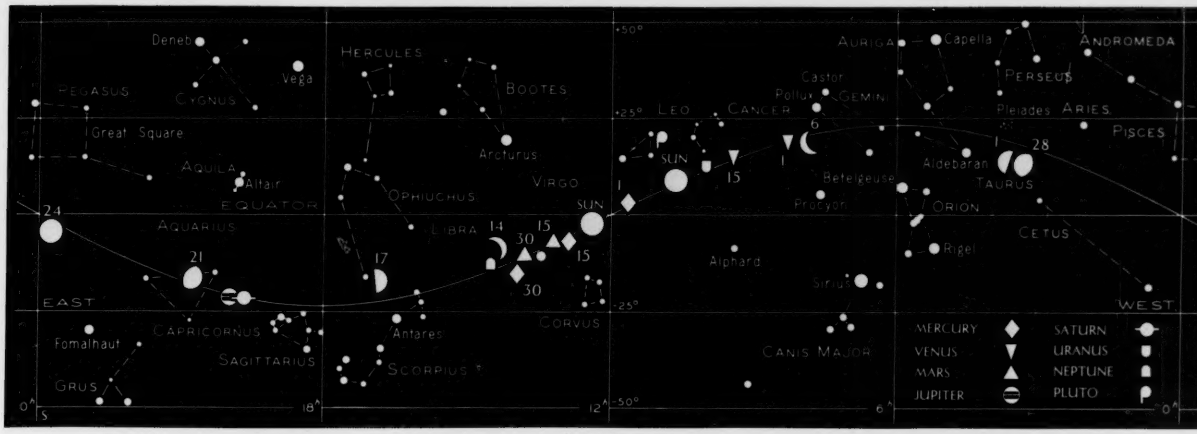
MINOR PLANET PREDICTIONS

On September 7th, Pallas (2) reaches opposition in western Pisces, when it will be about magnitude 8.7. Eleven days later, on the 18th, Juno (3) will be at opposition near the Pisces-Aquarius border, its magnitude being 7.7. A chart showing the paths of both of these asteroids was published on page 151 of the March issue.

Papagena, 471, 9.7. September 28, 2:06.4 −12-50. October 8, 1:59.5 −13-31; 18, 1:51.0 −13-48; 28, 1:42.0 −13-37. November 7, 1:33.8 −12-55; 17, 1:27.6 −11-42. Opposition on October 22nd.

Hebe, 6, 7.6. September 28, 2:18.2 −11-58. October 8, 2:13.9 −14-09; 18, 2:07.2 −15-54; 28, 1:59.6 −16-59. November 7, 1:52.7 −17-17; 17, 1:47.6 −16-49. Opposition on October 26th.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury, though at aphelion on September 16th and at greatest eastern elongation (26°) on the 28th, is unfavorably placed for mid-northern observers. Because its path carries it far south of the sun in the sky (12° on the 28th), Mercury will set only about an hour after the sun all month.

Venus rises nearly three hours before the sun in September and is conspicuous in the east during morning twilight. With a telescope examine the sky near it on the 22nd, when Venus will be $\frac{1}{4}$° east of Uranus, and also on the next morning, when it will be $\frac{1}{2}$° northeast of Regulus and some 80 times brighter than that 1st-magnitude star. On the 23rd, this planet will appear 12″.2 in diameter and 85-per-cent illuminated.

Earth reaches heliocentric longitude 0° at 6:43 Universal time on September 23rd. This is the moment of the equinox, autumn beginning in the Northern Hemisphere, spring in the Southern.

Mars, of magnitude +1.9, sets only about an hour after the sun and will be difficult to see all month. In fact, the red planet will not be easily observed until well into next year.

Jupiter is prominent in Sagittarius, about 5° east of Saturn. Brilliant at magnitude −2.2 in mid-September, the great planet crosses the meridian some two hours after sunset and is visible in the southwest until it sets about an hour past local midnight. Telescopically, Jupiter's flattened disk has an equatorial diameter of 44″.3 at midmonth, 3″.0 greater than its polar measurement. The planet becomes stationary in right ascension on the 23rd, then resumes eastward (direct) motion among the stars. The waxing gibbous moon passes 3° north of Jupiter at 5^h UT on September 20th.

Saturn, magnitude +0.6, is in Sagittarius and sets just after local midnight. Its polar and equatorial diameters on the 15th are 15″.8 and 17″.6, respectively; the major axis of the ring system is 39″.7. On September 27th Saturn will be stationary in right ascension, before resuming direct motion in the heavens.

Uranus will be difficult to locate in the morning sky except on September 22nd, when this 6th-magnitude planet will be in conjunction with brilliant Venus. Its 1950 co-ordinates on that date are right ascension 10^h 01^m.8, declination +12° 50′.

Neptune sets two hours after the sun this month, and thus will be hard to observe. The 8th-magnitude body is in Libra, its co-ordinates on the 15th being 14^h 29^m.5, −12° 55′ (1950).

WILLIAM H. GLENN

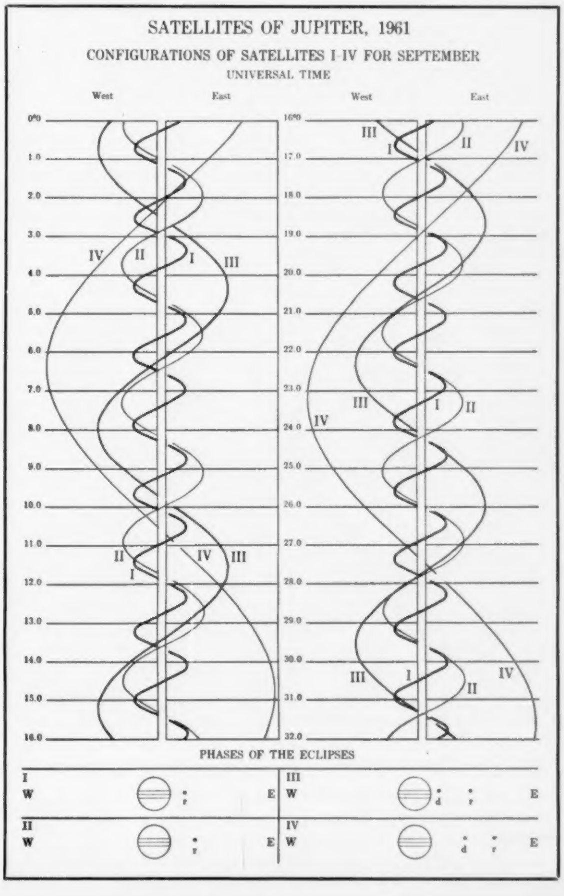
UNIVERSAL TIME (UT)

TIMES given in Celestial Calendar are Universal time (Greenwich civil time) unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th and to 10:15 p.m. PST on the 14th.

JUPITER'S SATELLITES

The four curving lines represent Jupiter's four bright (Galilean) satellites: I, Io; II, Europa; III, Ganymede; IV, Callisto. The location of the planet's disk is indicated by the pairs of vertical lines. When a satellite passes in front of Jupiter, its curve crosses the lines. If a moon is invisible because it is occulted by Jupiter or is in the planet's shadow, the curve is broken.

For successive dates, the horizontal lines mark 0^h Universal time, or 7 p.m. Eastern standard time (4 p.m. Pacific standard time) on the preceding day. Along the vertical scale, 1/16 inch is about seven hours. In this chart, west is to the left, as in an inverting telescope for a Northern Hemisphere observer. At the bottom, "d" is the point of disappearance of a satellite in Jupiter's shadow; "r" is the point of reappearance. From the "American Ephemeris and Nautical Almanac."



STARS FOR SEPTEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 21st of September, respectively; also, at 7 p.m. and 6 p.m. on October 7th and 22nd. For other dates, add or subtract ½ hour per week.

Though the northern Milky Way dominates the sky at chart time, popular Pegasus is well up in the east. Its Great Square can be picked out easily by the beginner. To the south of this configuration is the Circlet in Pisces the Fishes, with five 4th- and 5th-magnitude stars.

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